The Journal

of the

Astronomical Society of India.

EDITED BY J. J. MEIKLE, ESQ.

VOL. II.

November 1911 to July 1912.

CALCUTTA :

PRINTED BY MOTI RAM AND PUBLISHED FOR THE SOCIETY
BY RAI SAHIB M. GULAB SINGH & SONS,
76, LOWER CIRCULAR ROAD.

Price to non-members: Rupees thirteen and annas eight.

Price to members: Rupees six and annas twelve.

Index to Volume II.

A.

B.

C.

D.

E.

G.

H.

L.

M.

N.

O.

P.

R.

S.

T.

Officers and Council.

For the Session 1910-1911.

President:

H. G. Tomkins, Esq., F.R.A.S.

Vice-Presidents:

C. Michie Smith, Esq., C.I.E., F.R.S.E., F.R.A.S.
Saroda Charan Mittra, Esq., M.A., B.L.
Dr. Gilbert Walker, M.A., F.R.S., F.R.A.S.

Secretaries:

W. G. Burn, Esq., B.Sc. | P. N. Mukherji, Esq., M.A., F.S.S.

Treasurer:

U. L. Banerjee, Esq., M.A.

Directors of Sections:

General Section . .	E. P. Harrison, Esq., Ph.D.
Lunar Section . .	H. G. Tomkins, Esq., F.R.A.S,
Meteor Section . .	B. M. Rakshit, Esq., B.A.
Variable Star Section.	Lt.-Col. Lenox Conyngham, R.E., F.R.A.S.
Director of Photography	R. J. Watson, Esq.
Instrumental Director .	S. Woodhouse, Esq.

Librarian:

Ashutosh Mittra, Esq., M.A.

Editor:

J. J. Meikle, Esq.

Other Members of the Council.

P. C. Bose, Esq.	Dr. A. L. Sarkar, L.M.S., F.C.S.
P. L. Ganguli, Esq., M.A., F.R.A.S.	C. K. Sarkar, Esq., C.E., M.S.A., M.S.E.
H. B. Holmes, Esq.	W. J. Simmons, Esq.
J. C. Mittra, Esq., M.A., B.L.	Mrs. E. Voigt.
C. W. Peake, Esq., M.A.	

ERRATA

For Vol. I. No. 10, *Read* Vol. II, No. 1,
and renumber pages 1 to 29.

The Journal of the Astronomical Society of India.

VOL. I.] SESSION 1910-1911. [No. 10.

Report of the Annual General Meeting of the Society held on Tuesday the 31st October 1911.

H. G. TOMKINS, F.R.A.S., *President* in the Chair.

The Annual General Meeting of the Astronomical Society of India was held in the Imperial Secretariat Buildings (ground floor) on Tuesday, the 31st October 1911, at 5 P. M.

The President opened the proceedings and Mr. U. L. Banerjee read the minutes of the last monthly Meeting, which were duly confirmed.

The election of the following members by the Council were then confirmed :—

1. A. H. MORGAN, ESQ.

2. E. C. GREEN, ESQ., B.A.

The Secretary then announced the following presents and donations given to the Society :—

(*a*) The Map of the Moon by Goodacre—by the President.

(b) 7 Volumes Astrographic Catalogue 1900, Oxford Section, by Prof. H. H. Turner, Oxford.

(c) Astronomical and Magnetical and Meteorological observations made at the Royal Observatory, Greenwich, by the Astronomer Royal.

(d) A donation of Rs. 100 to the Society Library given by H. H. The Maharaja Rana Bahadur Sir Bhowani Sing of Jalawar.

The thanks of the Society were accorded to the donors.

The Secretary then read the Council's Report of the Society with the remarks of the Auditor on certain items of the Balance Sheet for the season 1910-11. The President having explained the reason for which these items had been included, the Report was adopted.

The President then gave a presidential address touching upon the following subjects :—

(1) The report and progress of the Society.

(2) The progress of Astronomy during the year.

(3) The origin of Lunar Craters.

The result of the Election of the Council for the Session 1911-12 was then announced by the Scrutineers, and votes of thanks having been passed to the members of the retiring Council, the Auditors and the Scrutineers of the ballot, the Meeting was adjourned until Tuesday, the 28th November 1911.

The Report of the Astronomical Society of India for the year ending 30th September 1911.

The Council beg to submit the following Report of the operation of the Astronomical Society of India for the year ending 30th September 1911.

2. *Members.*—The Society entered on its first session on 1st October 1910, with 192 original members and 66 new members were elected during the year, giving a total of 258. Of these 13 members withdrew without paying their subscrip-

tions, 3 resigned and 1 died after paying the subscription for the entire year while 2 resigned after paying only the 1st instalment of the subscription. The number thus stood at 239 on 30th September 1911.

3. *Casualty.*—The Council record with deep regret the death of one of their early members in Mr. Goulsbury.

4. *Meetings.*—The Council held 9 ordinary Meetings and one special Meeting during the session for discussing the transactions of the Society. Every such Meeting was well attended and the interest in the Society's business was well maintained by the members.

Nine ordinary Monthly Meetings of the Society were held generally on the last Tuesday of each month, every one of which was largely attended both by the members and their friends. The President himself presided over all the Meetings and a very keen interest was taken in the discussions of several Astronomical subjects brought before the Society. A pleasing feature of the Meetings has been the informal discussions afterwards, affording as they do an excellent opportunity for members to make each others acquaintance.

5. *Quarters.*—At first the Society had no fixed quarter of its own, its Meetings being held in different rooms of the Imperial Secretariat Buildings. The Comptroller General then very kindly placed a small room on the ground floor of the building at the disposal of the Society for its office and Library and also allows the ordinary Monthly Meetings to be held in the Building. The gratitude of the Society is due to the Comptroller General for his kindness.

To equip the room with necessary furniture, donations were presented by several members, and the Library room is now well-equipped with furniture, electric lights and fans; so that the members can conveniently read their Astronomical Papers, Books, Journals and without any inconvenience.

6. *Library.*—To give facilities to members, a Library has been started with valuable Astronomical Books purchased from England. A subscription list was opened for the purpose, to which the members gladly subscribed. Several members of the Society and several Astronomical Societies and Observatories of the world have also given valuable presents in the shape of Books, Journals and Catalogues, Atlases, etc., to the Society. The thanks of the Society are due to these donors, who have thus helped the cause of Astronomy in this country.

To conduct the business of the Library, bye-laws have been framed, and a Standing Library Committee has been appointed, consisting of the President, the Librarian and a Member. An Assistant Librarian and Office Superintendent has also been appointed on a monthly allowance to conduct the routine duties of the Library and the Society.

The list of books at present in the Society's Library has been published separately. They now number about 150 works. It may be added that the reading-room is open daily from 5 to 7 P.M. (except on holidays) for the use of members and facilities exist there for them to make use of the books of reference in the Library and to see the literature sent to the Society in exchange by other Societies and Observatories.

7. *Instruments.*—The Society has not as yet been able to purchase Astronomical Instruments of its own, but on several occasions the instruments of the Presidency College Observatory, kindly placed at the disposal of the Society by the College authorities, have been used. Besides those, some of the members of the Society have now instruments of their own, by means of which they make their observations and report the results to the Society.

A Director of Instruments has been appointed to advise the members on the suitability of different kinds of instrument and to arrange for their purchase. Several members have already procured instruments in this way. It is proposed very shortly to draw up a list of the instruments available in the hands of members and to take steps to assist their owners in making practical use of them.

8. *Society's Publications.*—Mr. Woodhouse, an energetic member of the Society, prepared a Star chart, consisting six plates, at his own cost, and placed it in the hands of the members in the beginning of the Session.

The Society published a Journal of its own, and issued it regularly every month for 9 working months of the Session. These Journals contained the proceedings of the monthly Meetings in full. The Astronomical papers read before the monthly Meetings, as well as extracts from important Astronomical publications, were reproduced therein. Several important Astronomical Photographs were reproduced in the Journal. The Society is specially indebted to Mr. Evershed, the Director of the Kodai Kanal Observatory, India, and Dr. Lowell of Flag Staff Observatory, America, in this matter.

9. *Recognition of the Society.*—At the beginning of the Session letters were addressed by the President to all important Astronomical Societies and Observatories of the world, asking for their co-operation in forwarding the cause of the Society, which is the first of its kind in India, by placing it on their lists of exchange. The following Societies and Observatories promptly responded to the appeal and have been regularly furnishing their publications, to the Society, in exchange for our Journals.

List of Societies and Observatories which make exchange with the Astronomical Society of India.

1. Royal Astronomical Society.
2. British Astronomical Association.
3. Astronomical Society of Italy.
4. Astronomical Society of Barcelona.
5. Royal Observatory of Scotland.
6. Vatican Observatory.
7. Royal Astronomical Society of Canada.
8. Astronomer Royal, Greenwich.
9. Royal Observatory of Belgium.
10. Director of Indian Observatories, Alipur.
11. Director of Kodai Kanal Observatory.
12. Oxford University Observatory.

10. *Society's Common Seal.*—A common seal, through the kindness of Lieutenant-Colonel Lenox Conyngham, R. E., F. R. A. S., was designed for the Society by Mr. F. C. Scallan. It is a representation of the Constellation Scorpio above Observatory set among palm trees, the whole surrounded by a border of lotus flowers with the words and figures "Astronomical Society of India, 1910."

11. *Steps taken to popularise the Society.*—With a view to help the members to understand the position of Constellations, Mr. B. M. Rakshit, the Director of Meteorological Section, kindly held certain in-door and out-door classes on the subject. The classes meet three times, but owing to the inclemency of weather much could not be done. It is proposed to start them earlier in the coming Session.

12. *Accounts.*—The accounts of the Society for the year under report are shown in the accompanying statements.

I. Revenue Account, Session 1910-11.

Expenditure.	Rs.	As.	P.	Receipts.	Rs.	As.	P.
				By Subscription—			
				Original Members 179 @ Rs. 8 ... = 1,432			
To Establishment	187	10	3	Elected Members { 58 @ ,, 8 ... = 464			
				{ 8 @ ,, 4 ... = 32			
, Cost of Stationery	31	3	6	Total amount due ... 1,928			
,, Postage charges	141	6	0	*Deduct* amount realised—			
,, Office Expenses and Miscellaneous ...	81	3	9	In Season 1909-10—			
				31 @ Rs. 8 ... = 248			
,, Discount for Cashing Cheques of Members ...	1	0	0	2 @ ,, 4 ... = 8			
				256			
,, Remuneration to Reporter	12	0	0	In Season 1910-11—			
				169 @ Rs. 8 ... = 1,352			
,, Printing Charges—				24 @ ,, 4 ... = 96			
				1,448			
				1,704			
Cost of Blocks, Photographers, etc. ...	448	13	0		1,448	0	0
Cost of Printing Journals	368	10	0	Amount in arrears 224			
Cost of Miscellaneous Printing	306	14	0	*Deduct* amount withdrawn 2 @ Rs. 4 = 8			
				216 (*a*)			
,, Cost of Furniture, etc., for Quarters ...	165	8	9	Subscription realised in advance—			
	1,744	5	3	3 @ Rs. 8 ... = 24			
				1 @ ,, 4 ... = 4			
				28	28	0	0

,, *Undisposed of Liabilities* :—		*By Entrance Fee*— Amount due 66 @ Rs. 4 ... = 264	
Add Outstanding Bills not yet paid by *Credits* to 'Suspense Account'	583 1 6	Realised in season 1910-11, 58 @ Rs. 4 ... ... = 232	
		1 @ ,, 2 ... ... = 2	
,, Depreciation in the Stock of Library Books ...	23 3 5	234	234 0 0
,, ,, in Furniture	15 3 11		
	2,365 14 1	Amount in arrears ... ... 30 (*b*)	
Add-Closing Balance of Revenue Account ...		By Interest on Deposit Amount in the Alliance Bank	7 12 0
		,, Sale of Journal	1 8 0
(Debit balance) ...	47 11 10	,, Miscellaneous Receipts	0 4 0
		,, Contribution towards Quarters	170 0 0
		Actual Receipts	1,889 8 0
		Add unrealised subscriptions as above (*a*) by *Debit* to Suspense Account	216 0 0
		,, unrealised entrance fee by *Debit* to Suspense Account (*b*)	30 0 0
		,, unrealised donation for quarters by *debit* to Suspense Account	10 0 0
			256 0 0
		,, opening Balances brought forward from account of Season 1909-10	172 10 3
Total ...	2,318 2 3	Total ...	2,318 2 3

U. L. BANERJEE,
Treasurer.

II. General Balance Sheet on 30th September 1911.

Liabilities.	Rs. A. P.	Assets.	Rs. A. P.
Sundry Auditors.—		Block Account ...	0 0 0
Undisposed of liabilities		Library *Stock* of Books.	
Bills outstanding—		Cost price ...	464 4 4
Rai Sahib M. Gulab Singh & Sons, for printing charges ...	583 1 6	*Deduct* 5% depreciations charged to Revenue Account 23 3 5	
		443 0 11	443 0 11
		Furniture. Cost prices	152 7 0
		Deduct 10% depreciation charged to Revenue Account 15-3-11	
		137-3-11	137 3 11
		Unsold Journals 2,054 copies @-/4/- per copy on average ...	513 8 0
		(As per stock Register)	
Revenue Account—		*Sundry Debtors*— Unrealised assets as per Suspense Account—	
Balance of Revenue Account ...	47 11 10		
Library Account—		Subscriptions ...	216 0 0
Balance of Library Account	65 11 8	Entrance fee ...	30 0 0
		Donation for quarters	10 0 0
Deposit Accounts—		Donation for Library	38 0 0
Balance of Deposit Account ...	25 0 0		1,387 12 0
	626 1 4	Cash balance in the Alliance Bank of Simla, Limited ...	352 12 2
Excess of Assets over Liabilities ...	1,132 3 4	Cash with Treasures ...	17 12 6
			370 8 8
Total ...	1,758 4 8	Total ...	1,758 4 8

U. L. BANERJEE,
Treasurer.

Auditor's Remarks.—Accounts examined and found correct. The estimated value of the stock of Journals seem to us to be greatly in excess of the true value.

G. LEATHAM.
H. C. BANERJEE.

23-10-11.

Council's Remarks.—The Council considers that the back numbers of the Society Journals will increase in value as the time passes on, and will be wanted by new members on admission into this Society. The value accepted for account purposes of As. 4 is only $\frac{1}{3}$rd of the sale price to members and $\frac{1}{6}$th of this sale price to outsiders. In the absence of some exact data, and in view of the fact that its omission would not affect the stability of the Society, they consider it advisable to retain the item at its present figure.

P. N. MUKHERJEE,
Secretary.

Annual Address by the President.

It is customary for the two Astronomical Societies in England from whose experience and procedure our Society in India has largely profited during the first year of its existence to treat one Meeting out of the nine in each Session as its annual General Meeting. At this Meeting, the Society transacts its annual business such as the adoption of its report, the election of its Council and other matters provided for in its regulations and it allows the retiring President the privilege of delivering to members an address in which he usually touches on the progress and work of the Society, the progress of Astronomy generally during his year of office and finally some phase of Astronomy which he has made his own subject or which he may specially select for the occasion.

The Astronomical Society of India has selected the meeting held in October as its Annual General Meeting, and this is the first occasion on which that meeting is held. It has consequently fallen to me as your first retiring President either to follow or to ignore the precedents I have referred to. As against such an address it may be said that here in India we have not nor are likely to have as a rule a large field of professional astronomers such as exist in England from whom it will be possible to elect a President, and the necessity of our President being resident in Calcutta owing to the extent of India as compared with England further narrows the choice.

This being the case, a President of the Society in India may feel, as I do myself, that his address cannot always carry the weight or have the value of those professional discourses to which Fellows and Members of Societies in England have the pleasure of listening. On the other hand, however, the address permits of the President once a year setting before the members of the Society many matters connected with its management and progress for which there is no other opportunity it enables him to sum up the progress of the Society and to review the work of members, and it also affords an opportunity of placing the Society and its doings before the public, an important matter if it is to attract other members into the same field of Science. In addition to this, it enables the President to bring before the Society a brief outline of the general Astronomical progress made by astronomers during his term of office. However great his diffidence or humble his ambition, it does not seem to me that a President need be deterred from proceeding thus far. As regards the more personal portion of his address, it is I think reasonable to assume that our Presidents shall either in the course of their reading or of their observation have had some direction in their Science on which to concentrate their ideas more than others, and it will be his privilege, as I feel it is mine, to be allowed on one occasion in the year to talk to his fellow members on that subject.

With this introduction therefore I have decided to inflict on members the first presidential address of this Society and for a few minutes I would ask for the exercise of such patience as you may be able to command.

First as to our own Society.

As members are aware, the Astronomical Society of India was founded on the 26th July 1910, on the initiative of a few gentlemen interested in the subject in Calcutta, and it is unnecessary for me to enter into the history of its institution as it has already been given in the first number of our Journal. We have now just closed the first year of our existence. I need hardly remind you however that the Society is still and will be for the next few years in its infant stages and that consequently it will need all the support it can get from its members. To make it thrive, members must not only themselves take an interest in its work, but must also induce others to do so, and to become members. The report which has just been read shows us that our infant is strong and healthy and there is no reason why it should not in time grow to attain the proportion and position which we all desire. The member-

ship of the Society starting with 192 increased by 47 making a net membership on the 30th September 1911 of 239. Not less promising are the finances of the Society. It has of course been necessary to exercise rigid economy owing to the low subscription of eight rupees a year. That the decision to fix this low figure was justified is borne out by the fact that it has enabled several members possessing only small means to join us in our pursuit after knowledge in the Science, to whom a higher subscription would probably have been prohibitive. As you will see from the accounts, a certain amount of initial cost was inevitable in starting the Society. Apart from this and our current office expenditure which is not high, the main item has been the printing of our Journals. In these the Council have been guided by a desire to make them as attractive as possible to members, to illustrate as freely as means allowed of, and to reproduce the papers of those who were kind enough to contribute as well as could be done. In this I think members will agree that our Editor has been successful and I am sure that they will be glad to hear that our Journal has already made for itself a welcome on the tables of the English and other Societies and this more especially on account of the illustrations which we have been able to reproduce.

An institution which has made especially good progress in the way of getting itself into order is the library and reading room, and I hope that this will be increasingly used by members. Several members have already patronised it, but the fact that the room is open every evening and has lights and fans is not as extensively known as we should like. There are now over 150 volumes on our shelves, and most of these can be borrowed by members both in and out of Calcutta.

As might be expected, our first year has been spent largely in feeling our feet and gaining experience of the conditions which will be most suitable for an Astronomical Society in India. The Council had the benefit of much that had been done by other Societies and this was particularly the case with our bye-Laws and general procedure. We could not hope, however, to leap into an advanced stage of work at a single bound, and during the year many directions have come to notice which must claim the attention of the Council for 1911-12. Foremost among these is the fact that we must get into closer touch with our members outside Calcutta—more especially those possessing means of observation. Distance in India is a great obstacle in the way of systematic co-operation in Scientific work, and the Directors of our sections have come

up against this difficulty. The experience has brought forth suggestions for a remedy and they are ready for our new Council to consider.

Another direction, and an important one, in which experience has shown us room for activity is that of our members who are beginners in the study of the Science. Something was done last year but I hope we shall see a very much wider and more effective move this year. We have now got the want defined and it will not be difficult I hope to supply it.

Our most active section and the one most fruitful in results was undoubtedly the Meteoric Section. The Director is to be congratulated on the contributions his section made to the Journal and particularly on the specimens of the Meteorites kindly sent to the Society by one of our members, His Highness the Maharaja of Jalawar. In the opinion of Geologists who have seen the pieces, the Society has already justified its existence in the matter alone of having been a means through our members of rescuing these important specimens from possible loss.

The next most successful Director has been Mr. Woodhouse in charge of the work of advising members as to instrumental equipment. Several members have either set up an instrument or are in the course of doing so, and in the early stages of a Society such as this in India in which amateurs are being made, one of the first and most important matters is adequate advice to those who wish to secure equipment and make a beginning. To assist them in using their instruments when bought will I hope be an item on the Society's programme this year.

Mr. Mitchell, our Director of the Lunar Section, has prepared a handy map of the Moon for the Society. I hope this will issue shortly.

Ladies and Gentlemen, the Astronomical Society of India has been launched, and it is making its way. It has now reached a stage at which the feeling of novelty among its members should be wearing off and they have gained some idea of what they want and what has to be done. It remains for them to actively do it. One of the first duties of the new Council will be to consider a programme of operations for the year and I have no doubt that you will very shortly have an opportunity of taking your part in it. Apart from this, however, every member can assist in making the existence of the Society known in India.

A beginning—and I think a satisfactory beginning—has been made, but we must not stand still. The Society wants interest in its doings widely spread and it wants more members. I should like to see our membership well over 500 during this Sessions. It is commonly thought by those who are interested in the subject, that their joining the Society will not advance its objects, because they do not happen to possess a telescope, or perhaps have not very deeply studied Astronomy. In this they are greatly mistaken. The mere fact of a member joining the Society does two things to further its progress ; it tends to widen the interest taken in the subject and encourage others to think about it, and secondly by means of the subscription it enables the Society to definitely enlarge its sphere of action. The money is not sunk in things which give no return. Up to the present it has been mainly spent on the publication of the Journals, and on books for the Library. The means of the Society have been severely limited and much else has not been possible. We have suggestions, however, for an instrument and Observatory for the use of members and yet another for the provision of a few instruments which we could place in the hands of members out of Calcutta on loan in the same way as is done by the British Astronomical Association in England.

Again there are suggestions for classes and lectures. All these things demand funds, and members who join the Society, whether they are active amateur astronomers or not, can effectively secure these objects to the advancement of Science in India and can themselves take part in it if they will. The Society must keep within its means and its own sphere of action. Those means and that sphere of action are limited only by its membership and by the extent of the interest which is aroused in the Science.

Let us now leave our particular affairs and for a few moments recall a few of the Astronomical events of the year just passed.

On the 28th April this year a total eclipse of the Sun occured to observe which parties visited the Friendly Islands in the Pacific Ocean. The place best situated for the eclipse was Vavau and here were parties under Father Cartie, Director of the Solar Section of the British Astronomical Association, Mr. Frank McClean and Dr. Lockyer. The weather greatly interfered with the scenes of the observations, but in spite of it, a few good photographs were obtained. Mr. Wragge at Lifuka, however, had better fortune. The Corona was typical of the minimum sun-spot period and the Hydrogen prominences were well seen. A matter to be noted by

observers in the case of future eclipses is one which has also previously made itself prominent—namely the importance of taking advantage of as many different stations as possible. The weather at Vavau, the favourite place, was bad during the eclipse but cleared up almost immediately afterwards. At Lifuka, however, not perhaps so well suited in many ways, weather favoured the observers.

Some of the most important work on the Sun has been that accomplished at the magnificent Observatory at Mount Wilson in America under the direction of Professor Hale in connection with magnetic fields in the region of Solar spots and at the Kodai Kanal Observatory by Mr. Evershed on the radial outflow of vapours from the interior of sun-spots. On page 110 of the Journal of this Society will be found a brief explanation of what is known as the Zeeman effect and members may remember that Mr. Evershed very kindly sent us some slides during the Session showing this. I will quote Dr. Harrison's explanation. The effect is the splitting up of what is normally a single line in the spectrum into two or more lines and it can be accounted for by assuming the atoms of matter to be associated with small electrically charged particles (electrons) of definite mass, the orbital vibrations of which give rise to light. Any particular wave length (and therefore any particular line in the spectrum of a glowing gas) is associated with a particular configuration of certain groups of electrons. A magnetic field will in general disturb the configuration giving rise to one or more different periods of vibration, which is made evident to us as a doubling or trebling of what was originally a single line in the spectrum.'' This peculiarity was first seen in the solar spectrum at the Mount Wilson Observatory, and investigations into the nature of these magnetic fields have continued since.

Probably not unconnected with them is Mr. Evershed's discovery of radial motion in sun-spots. He noticed in 1909 that there was a displacement of the lines crossing a sun-spot photographed on the 7th January 1909, as compared with the lines in the neighbouring photosphere. The measurements indicated a receding movement on the north-west side of the spot and an approaching movement on the south-east side. This appearance suggested the rotation of the absorbing gases in the penumbra arising from a rotation of the spot as a whole about a point at its centre. This theory has been developed by Mr. Evershed and during the year 1910, a paper appeared in the monthly notices of the Royal Astronomical Society on the subject, to which I must refer members for details. Briefly, however, Mr. Evershed found evidence of

the displacement in every photograph of any considerable spot which he had taken during the year. The conclusion he arrived at was that "spots are the centres of a force directed radially outwards in a horizontal plane acting continuously on the materials of the reversing layer over the entire area of a spot and maintained throughout the life of a spot. Whether this is causative of the magnetic field or not, or whether the two were intimately connected, there was not sufficient evidence to show, but there were certain characteristics which supported the idea.

A labourious piece of work on the Sun which came to a satisfactory conclusion during the year, was the determination of the solar parallax by means of the observations of Eros. On August the 15th, 1899 a minor planet was discovered by Herr Witt at Berlin. It turned out to have an orbit between the Earth and Mars instead of between Mars and Jupiter, as is usual with other minor planets. This peculiarity gave our little neighbour an importance it would not otherwise have possessed, as its proximity when in opposition enables us to determine the distance of the Earth from the Sun with an accuracy that has not been possible by any other methods. The opposition of the planet in the year 1900 was made use of, and photographs and measurements were taken at several of the more important Observatories in the world. The result was an accumulation of data which had to be put through the mathematical mill to bring out the desired results. This reduction of the observations was taken in hand by Mr. A. R. Hinks of the Cambridge Observatory and the result was published in 1910, the parallax being $8{\cdot}806'' + {\cdot}004$. The value hitherto adopted in the Nautical Almanac has been $8{\cdot}80$: so that the adoption of this figure has been justified and the agreement is pretty close. The mean distance of the sun from the Earth derived from this value is about 92,800,000 miles. Turning now to the Stars, we have the progress of the two-stream theory regarding which I would refer members to the Monthly Notices of the Royal Astronomical Society, and for a general description of some phases of the theory to my paper in the Journal of this Society for February 1911. Following on the work already done, the Stars in Orion which had shown peculiarities of their own, have been further investigated and afford evidence of a third minor stream. The appearance of Boss's Catalogue of 6,180 stars for the repoch 1900 has furthered these researches.

The photography of the sky in the hands of Professor Ritchie at Mount Wilson has made enormous progress, the detail and definition of some of his recent photographs

being wonderful. I hope that we shall have some of these to show later on at some of our Meetings reproduce in our Journals.

A Nova was discovered in the constellation of Lacerta on the evening of Friday, the 30th December, by Revd. T. E. Espin, an English amateur. It was slightly brighter than an 8th magnitude star at the time of discovery and red in colour. The star quickly declined and by the middle of February had dropped nearly to the 9th magnitude.

The year was a great one for Comets. During 1910 we had two large Comets,—Halley's and the one known as the Day-Light Comet, and during 1911 there have been seven, one of which was Enck's Comet. Two are visible to the eye or are easy telescopic objects. As members will remember, Halley's Comet appeared at the end of 1909, transited the Sun in May 1910 when the Earth passed through its tail, and then appeared as a fine object in the evening skies until it disappeared. It was photographed at the Helwan Observatory so late as November 1910. I suppose that a feature about the return of this Comet which will be accounted one of the most notable was the extraordinary accuracy with which Drs. Cowell and Crommelin of the Greenwich Observatory predicted its perehelion passage for which they well earned the honours they received. A series of photographs was obtained at Kodai Kanal, some of which members have had the pleasure of seeing in this room.

The Day-Light Comet appeared in January 1910 and was first seen in the Orange Free State on the 15th of that month. Two days later it was seen by Mr. Innes at Johannesburg. The Comet was a brilliant object in Africa and Europe but was not well seen in India, though for a few evenings it was conspicuous in the evening twilight just after sunset. It had a tail about 20° in length.

The brightest Comet this year has been Comet c of 1911 known as Brooke's Comet. It was a naked eye object in September last, its light on the 20th September being equal to a 3rd magnitude star. It developed a tail, and a photograph taken at Chester shows it with a large round head and a tail of six or more straight streamers from it. It is now a morning object and its position to-night will be about 12h-33m in R. A. and 22′ N. Dec.

Another Comet easily visible in the telescope is that of Borrelly (1905-11). It is a periodic Comet and was easily found from the elements of its orbit by Mr. Knox Shaw at

Helwan in Egypt. This Comet is likely to be an easy telescopic object in December and is one that members possessing instruments might well watch.

I come now to the Moon, and at the outset must be mentioned two important contributions which have been placed in the hands of selenographers.

I refer to Mr. Saunder's determinations of selenographic positions and measurements of lunar photographs and to Mr. Goodacre's magnificent map of the Moon. In the former work selenographers have a very large number of points on the lunar surface accurately measured on which it has been possible among other things to base a revised map of the Moon. Mr. Goodacre has utilised these measures, and as result we have his splendid map on the scale of six feet to the Moon's diameter, the details of which are up to date. There is no doubt that in Lunar work these two contributions are invaluable productions, such as have not appeared for many years, and will become standards for a long time to come. Members will find a copy of the map in the Library. A matter which has engaged the attention of astronomers for some time is the system of Lunar nomenclature. As you are aware the formations on the Moon,—I speak especially of those known generally as the craters—have many of them received names which have been given to them after persons of fame such as Plato, Copernicus, Tycho, &c. Had the naming ended there no difficulty would probably have arisen, but as knowledge of the Moon extended names were given to more and more of the formations, and many of them are unsuitable and chosen on no system whatever; some have no name at all, others have a letter of the alphabet to distinguish them and in some instances two craters have the same name. A Committee was accordingly formed some time ago to suggest a suitable system of nomenclature which can be generally adopted, and I was glad to learn while in England that the work was in progress. It is a matter which demands early attention so that the revised system may be capable of being adopted in new works that may issue in future.

And now I will turn to what may perhaps be called an Appendix to my address—namely some remarks on a subject of my own choosing. The President of the Royal Astronomical Society in introducing this feature into the Annual Address of that Society in 1909 remarked that it was a beginning which might serve either as a sign-post or a tombstone and added that it was his hope that future Presidents might from time to time be willing to use his action as a

precedent for speaking freely at the annual meeting. It was his hope, however, that no President would feel it in any way incumbent upon him to speak if speech would be an unbearable or unwelcome burden. Mr. Newall on that occasion expressed exactly my feeling this evening and it has peculiar force in the first annual address of our Society.

The subject on which I would ask your attention for a few minutes is the origin of the Lunar Craters, and I do so more especially because this matter has recently been prominently before astronomers in the important work by Dr. See of America on the Evolution of the Stellar Systems. As the name implies, the book deals primarily with the birth and growth of the Universe and especially of a solar system consisting of the Sun and planets. Within this large subject the author treats also of the origin and regulation of Satellites to the planets and gives special attention to our own Satellite —the Moon. In order to make my remarks clear to you, however, it is necessary first of all to dwell for a short space on the aim of this remarkable book. We have all of us doubtless at some time or another wondered how our Sun and Earth and planets came to be, how the stars came to shine in our skies, whence they evolved and whither they go. This I suppose is the grand problem which the Science of Astronomy sets itself to solve, and towards the elucidation of this mystery most of the branches of the Science, such as the work on the Sun, Moon, Double Stars, Nebulae, Comets, &c. tend. The combination of all the forces, movements and other changes which take place in these details eventually constitute the evolution of the universe as a whole. It is not surprising therefore to find that theories to reconcile all these departments of Astronomy and to weave them all into a working whole are not frequently propounded or that this enormous problem is one which a single man is rarely able to seriously undertake. The theory which has hitherto held its ground is that of Laplace which was promulgated in the year 1796 and was known as his Nebula Hypothesis.

This hypothesis assumes as a basis a central nebulous mass and supposes it to attain a rotatory motion which gradually increases in speed until the acceleration is such as to cause it to part asunder. So gradual, however, is the acceleration in the enormous lapse of time through which the events occur, that there is no violent disruption, but the central mass throws off a ring which itself gradually condenses into a smaller mass itself rotating and having an orbit at the site of the ring. This orbit might of course and would probably be modified by later events. The central mass con-

densing and again accelerating its rotation would then again throw off a second ring, and so on, thus forming the planets. These planets in the same way would throw off Satellites. Thus eventually we are left with a central Sun, the planets round it and the Satellites again round them. These bodies have gradually cooled and solidified or are in process of doing so. Working on this hypothesis Sir George Darwin has found mathematically that even the Earth and Moon revolving very close to one another at some previous time, the tidal friction generated would be sufficient to bring about the present condition of those bodies. This theory has been generally accepted by astronomers to the present day. The work of Dr. See has for its object to show that the hypothesis of Laplace and the deductions of Darwin and others are erroneous, and that the true process of evolution is the reverse of what they suppose, namely a nebulous stream of what he terms cosmic matter which is set in rotatory spiral motion by coming into contact with another such stream. The two streams then form a spiral round each other, thus becoming what are known as the spiral nebulæ. The central mass gradually accumulates the cosmic matter to itself and on meeting other masses of the same kind captures them by its force of gravitation and the captured body then revolves round the original mass as a planet. Similarly the captured body may itself capture other smaller bodies which will then revolve round their primaries as Satellites. In this way Dr. See believes our Moon to have once been outside the orbit of Neptune and there captured. It will be asked how the orbit has diminished to its present size and the same question applies also of course to the planets themselves and other Satellites. The answer Dr. See gives is that the whole system has at one time been filled with what he terms cosmic matter and that the resistance caused by this matter to the revolution of the captured bodies round the central mass has gradually reduced their orbits and rendered them nearly circular until they have attained their present size, the action now having stopped or nearly so owing to the disappearance of the cosmic matter which has gradually been accumulated on the surfaces of the planets (thus building them up), until no more is left. Dr. See gives mathematical proof that a resisting medium such as he assumes would reduce orbits in the way he describes, and possibly it would do so. But it seems to me at the very outset we come up against a difficulty which is likely to vitiate the whole theory. This is the resisting medium which Dr. See calls cosmic matter and which he defines as "composed of cosmical dust, true physical matter, not ether." Again he supposes nebulæ to be caused by the automatic winding up of two or

more streams of cosmical dust. "Indeed" says he "two such stream cannot meet or a single stream settle to equilibrium without giving rise to rotation about a centre, and thus producing a whirling vortex which eventually leads to the development of a cosmical system." This dust Dr. See considers is the result of "an expulsion of cosmical dust under electric forces and radiation pressure of the light of stars to form nebulæ." It is clear therefore that Dr. See contemplates real ponderable matter, *i. e.*, dust in the sense usually implied by the word, and this is also evident from the portions of the book which deal with meteors and meteoric dust—the latter being evidently the cosmical dust itself and the former simply small accretions of it. Now the dogmatic assertion that such cosmic dust once pervaded our system which is repeated over and over again through the book does not prove that it ever existed. There is a great difference between assertion and evidence, and as far as I am aware there is not evidence that such dust ever did pervade our system, that nebulæ are composed of such matter, or that any traces of such quantities of cosmic matter exist in the solar system to-day, in fact Dr. See himself admits the rarity of the last named. On the assumption of the existence of this dust, however, the whole of his fabric rests and consequently it seems to me that the verdict must be one of not proven on this ground alone apart from many other considerations which are to be found in the work. Coming to the Moon which is our subject, Dr. See considers it to have been captured on the outskirts of our system and its orbit to have been narrowed down by the resisting medium of the cosmical dust. He does not hold that volcanic action has caused the craters on the Moon, but thinks that on its journey from the outer part of the system to its present orbit it has suffered severe bombardment from meteors from other bodies which it has encountered on its way and which are still continually falling and go to make up the planets and Satellites and even of the Sun itself. He considers these meteors are mainly encountered among the asteroids between the orbits of Mars and Jupiter. As an instance of the extraordinarily slender data on which Dr. See builds up these assumptions, I may mention that he considers the surfaces of Mercury and all Satellites to be similarly marked to our Moon. This he concludes from certain observations of his own. He says, "In this connection I may say, that on one or two occasions when the seeing was at its best during the observations of the planet Mercury at Washington in 1901 and 1902, I believed I obtained glimpses of the planets' surface of the same type as the Moon. It may well be that these brief glimpses,

gained at moments of best seeing, supported as they are by the evidence of photometric measures, showing that the planet has a rough surface, rest on a more substantial basis than any one has heretofore ventured to believe. One gets the impression that the origin of the Moon and of the planet Mercury is essentially the same, and that in the remote past both revolved in the planetary spaces between the present orbits of Mars and Jupiter." It will be noticed that peculiar as the suggestion is, it is more or less tentatively put forward in this place. It is the more difficult therefore without further explanation of any kind to understand the following unqualified decision on this point. It runs as follows:—"But if we consider a small planet such as Mercury which cannot retain or build up an atmosphere of much density, owing to its feeble power of gravitation, we shall perceive that its surface ought to be similar to that of the Moon covered with great indentations and streaks due to the impact of Satellites." By this we gather that the indentations would occur owing to the lack of the atmosphere to protect the planet. Dr. See continues: "Now in 1901 while observing under the best atmospheric conditions with the 26" Equatorial at Washington, the author obtained the impression that the planet Mercury actually has a surface similar to that of our Moon. In view of our present knowledge of the causes which have produced the craters and larger markings on the Lunar surface" (by which is evidently meant the impact theory which he adduces) "it is impossible to doubt that the impression gotten at Washington rests on a real foundation. We may therefore safely conclude that all the smaller planetary bodies, such as Mercury and the Satellites, have battered surfaces essentially analogous to that of the terrestrial Satellites which alone admits of minute telescopic investigation."

In regard to this sweeping conclusion it must first of all be said that beyond one or two very faint shadings on the planet Mercury, which have not even been sufficiently clear to enable its rotation period to be determined definitely, no other observer has ever been able to detect detail on the surface of the planet Mercury. If Dr. See saw features of the kind which exist on the Moon, the observation was one of the most remarkable in the investigation of Mercury and should certainly not have rested with one or two glimpses. Until the observations are confirmed by other observers, however, the conclusion that what Dr. See saw was formations similar to those on the Moon are scarcely likely to be accepted and the sweeping application of the idea to all the smaller planetary bodies can certainly not be seriously considered.

It is evident that the impact theory of the origin of the Lunar craters with the capture theory have brought the author up against a difficulty in regard to Mercury and the other Satellites. If the craters on the Moon originated by impact of meteors, there is no reason why such features should not also exist on the Earth as remnants of a similar bombardment unless it has been protected by its atmosphere or has suffered from a very much more serious fall of the cosmic dust than the Moon, which is scarcely likely. We are driven therefore to the conclusion arrived at by Dr. See, namely that other Satellites and perhaps also Mercury ought to possess similar features. Of this, beyond the glimpses which the author describes, there is not an atom of evidence, and this fact alone must therefore render it very doubtful whether the formations of the Moon owe their origin to the impact of Satellites or meteors. The impact theory as now put forward depends on the Moon having originated beyond the orbit at any rate of Jupiter and having suffered bombardment on its journey inwards between the orbits of Mars and Jupiter. This inward journey again depends on the action of a resisting medium composed of ponderable cosmical dust. In the present state of our knowledge there is, as far as I am aware, little or no evidence of dust having ever pervaded the system or of any impact by meteors in the case of any other body.

In treating of this subject I have not dealt with the question whether minute observation of the Moon's surface—and I suppose no other body has been so minutely studied—reveals any evidence of the impact by meteors. I think it may be said that it does not; on the other hand there is much to lead to the conclusion that the formations are the result of volcanic forces on the Moon itself. I may specially mention the white rays which surround the craters Copernicus and Tycho and several other formations. On the impact theory they are ascribed to the result of a meteorite striking the Moon. Dr. See says "My explanation is that a meteorite, striking the Moon with great force, spattered some whitish matter in all directions. Since gravitation is much feebler on the Moon than with us, and atmospheric obstruction of consequence does not exist, the great distance to which the matter flew is easily accounted for." In regard to this I can only say that having made a minute study of these ray systems for something over 14 years, they do not seem to me to have any great resemblance to matter splashed in the way described. To begin with many of the streaks—notably those round Copernicus and Tycho—lie along the crest of long low ridges, which at favourable times of the lunation have been well observed. The ridges

radiate irregularly from the central formation and are probably the result of the upheaval of the formation from below and possibly later subsidence when the volcanic action died out. It is not possible to conceive of matter being spattered precisely along the whole length of these ridges and not deviating from them.

Turning to the craters themselves, the most conclusive evidence against the impact theory and in favour of their volcanic character exists as might be expected in the small craters since we may there find some analogy on the Earth. Volcanic energy which has left its traces on the Moon must have been much greater than we are acquainted with on the Earth. This is not surprising when we take into account the difference in gravitational power. If therefore we wish to test the former presence of volcanic action on the Moon, we must begin by investigating formations which would compare with something of the same kind on the Earth. Now on the Moon we do find numbers of craterlets which give us the impression that they are volcanic. It can at any rate be said with fair certainty that they are not due to the impact of meteorites. For instance take a very common case of the chains of craterlets. They are common in the region of Copernicus, the wall of one lying up against that of the next and forming a chain of nine or ten in a row. It is impossible to believe that meteors striking the Moon's surface could cause such features. Along a line of weakness however nothing could be more likely than a chain of volcanic craterlets. Again there are cases of minute craterlets either near the tops or on the walls of larger formations. On the Earth we have Vesuvius and Etna as excellent examples of these phenomena.

It seems to me, however, that the enormous size of some of the formations is fatal to the impact theory. The smallest of the seas is over 300 miles in diameter and the others are much larger. The explanation of their smooth floors is by the impact theory, that the heat generated by the impact of the Meteorite was such as to liquify the surface and leave it level after the catastrophe. Considering the size of the seas and the fact that there are at any rate six of them to be accounted for, it is probable that the Moon would be disrupted altogether or at any rate the results would have been far greater.

I will not now occupy your time further. Those who wish for further evidence of the volcanic origin of lunar formations in preference to the impact theory will find a valuable paper on the subject in the Journal of the British Astronomical Association for October 1910 by Mr. Goodacre, the Director of the Lunar Section of that Association. He deals

there with particular characteristics of lunar formations which seem to me definitely against the supposition that they could have been due to impact by meteorites, much more Satellites. In my remarks, I have not taken quite the same line, but have attacked the theory from its improbability on other grounds. Both arguments seem to me to lead to the same conclusion—namely, that the impact theory must be abandoned. It is not generally held by those who have minutely studied the Lunar surface, but it has an extraordinary way of periodically re-appearing in fresh garb. On the present occasion it has been put forward by an able writer in Dr. See who has made the most of the arguments in its favour. On careful investigation I do not think it is likely to replace the volcanic theory of the origin of the lunar formations though I am far from thinking that there is not yet much more regarding them to be explained.

At an earlier stage of this address, I quoted some words of Mr. Newal, the President of the Royal Astronomical Society, which he used in adding his appendix to the address. I cannot do better in concluding this evening than by making use of him again and hoping than our Presidents will from time to time make our Annual Meeting an opportunity for a brief address on some subject of his own chosing, provided that we can avoid stereotyped action, which may easily come to impose an unnecessary tax not only on the President in the preparation of such an address, but also on the Society in listening to it: I trust that such a tax has not been imposed on you this evening.

Memoranda for Observers.

Standard Time of India is adopted in this Memoranda.

For the Month of December, 1911.

Sidereal time at 8 p.m.

				H.	M.	S.
December 1st	...	...	...	0	37	19
,, *8th*	...	...	...	1	4	55
,, *15th*	...	...	...	1	32	31
,, *22nd*	...	...	...	2	0	7
,, *29th*	...	...	...	2	27	43

From this table the constellations visible during the evenings of December can be ascertained by a reference to their position as given in a star Atlas.

Phases of the Moon.

				H. M.
December	*6th*	Full Moon	... ...	8 22 A.M.
,,	*12th*	Last Quarter	... ...	11 16 P.M.
,,	*20th*	New Moon	... ...	9 10 ,,
,,	*29th*	First Quarter	... ...	0 18 A.M.

Meteors.

There is one important shower in December—the Genrenids from the 10th to 12th.

Radiant Point.		Character.
R. A.	Dec.	
H. M.		
7 12	$+33°$	Swift Short.

Other showers occur on 4th, 6th, 8th, 12th, 22nd, 25th and 31st December.

Planets.

Venus.—Is a morning star. Its position on the 15th December at 8 P. M. will be R. A. 14 h. 21 m. 32 s. December 11° 20′-52″ S. The time of its rising will be 2 h. 42 m. A. M. on the 16th December.

Saturn.—The position of this planet on the 15th December at 8 P. M. will be R. A. 2 h. 49 m. 55 s. December 13°44′ 41″ N. The time of its setting will be 3 h. 18 m. A. M. on the 16th December.

Mars.—The position of this planet on the 15th December at 8 P. M. will be R. A. 3 h. 31 m. 18 s. December 21°4′1″ N. The time of its setting will be 4 h. 13 m. A. M. on the 16th December.

Jupiter.—The position of this planet on the 15th December at 8 P. M. will be R. A. 15 h. 56 m. 32 s. December 19° 39′18″ S. The time of its rising will be 4 h. 31 m. A. M. on the 16th December.

Notices of the Society.

Election of Members.

The attention of members is invited to Bye-Law No. 14, regulating the election of persons who desire to join the Society. It is hoped that those who are already members will induce others to join. Forms of application can be had from the Secretary, Mr. P. N. Mukherji.

The Library.

A subscription list exists and several members in Calcutta have subscribed and enabled the Council to make a beginning with the Library. Other members outside Calcutta, however, have not except in one or two cases yet come forward, and as the Library will be one of the most important adjuncts of the Society, and will be available to members both in and out of Calcutta, those who have not yet done so are invited to help the Society in making progress with this important branch of the work. Suggestions as to useful books for the Library will also be welcomed by the Librarian.

A number of books have already been received and can be borrowed by members in accordance with the Bye-Laws.

The books available can be ascertained from the Assistant Librarian and a catalogue will be issued shortly. The reading room of the Society in the Imperial Secretariat is now opened for the use of members daily from 5 to 7 P. M. except on Wednesdays and holidays and from 3 to 5 P. M. on Saturdays unless that day is a holiday.

Subscriptions.

Subscriptions for the current session fell due on 1st October 1911. Those who have not paid in their subscriptions are requested to remit them to the Treasurer at their convenience.

Papers for Meetings.

It is requested that drawings which accompany papers for reproduction in the Journal may be made with Indian ink on white paper. This will insure a clear reproduction.

List of Instruments.

With a view to enable the Council to obtain a knowledge of the instrumental equipment of the members, it is requested that those members who possess any instrument suitable for Astronomical work will kindly send details to Director of Instruments of its kind, size and power.

Programme of work for the Session.

Sub-Committee.—The Council have appointed a Scientific Sub-Committee consisting of the Scientific Secretary and the Directors of Sections. This Sub-Committee will direct the observational and educational work of the Society under the Council, and will consider in detail and take steps to introduce practical work. To begin with, the following are to be considered and taken up :—

(*a*) Instructions and classes for members who are beginners.

(*b*) Observational work for those members who will embark on it.

(*c*) Practical classes for members in Calcutta.

(*d*) Public lectures in Calcutta.

Members will shortly receive communications from the Sub-Committee regarding these matters.

Meetings for the Session 1911-12.

ORDINARY MEETINGS.

1911	1912	1912
November 28th	January 30th	April 30th
*December 26th	February 27th	May 28th
	March 26th	June 25th

The Meetings will commence at 5 P. M. and, until further notice, will be held in the Imperial Secretariat (Treasury) Buildings.

(* Subject to alteration under Bye-Law 85.)

Addresses of Officers.

Owing to inconvenience which has arisen from addressing the Officers of the Society at their private address, it has been decided to receive communications on the business of the Society in future as follows :—

	To
Money Orders or letters containing money or cheques	U. L. BANERJEE, Esq., Office of the Accountant-General, Bengal, 3, Koila Ghat Street, CALCUTTA.
All other communications	*(Name)*..........................Esq. (Designation.)................of the Astronomical Society of India, Imperial Secretariat (Treasury) Buildings, Calcutta.

It is requested that communications may be addressed accordingly.

Officers and Councils.

FOR THE SEASON 1911-12.

(1) *President* . . .	H. G. TOMKINS, ESQ., F.R.A.S.
(2) *Vice-Presidents* . .	(1) COL. S. G. BURRARD, R.E., F.R.S.
	(2) J. EVERSHED, ESQ., F.R.A.S.
	(3) SREE RAJA A. V. JUGGA RAO BAHADUR GARU, F.R.A.S., F.A.I., F.R.M.S., F.A.S. & C.
	(4) H. H. THE MAHARAJA RANA BAHADUR SIR BHAWANI SINGH, K.C.S.I., F.R.A.S.
(3) *Secretary (Scientific)* .	DR. E. P. HARRISON, PH.D.
Do. (Business) . .	P. N. MUKHERJI, ESQ., M.A., F.R.E.S., F.S.S.
Treasurer . . .	U. L. BANERJEE, ESQ., M.A.
Directors of Sections	
Lunar Section . .	H. G. TOMKINS, ESQ., F.R.A.S.
Meteor Section . .	B. N. RAKSHIT, ESQ., B.A.

Variable Star Section . Lt.-Col. Lenox-Conyngham, R.E., F.R.A.S.

Instrumental Director . S. Woodhouse, Esq.

Librarian—C. T. Letton, Esq.

Editor—J. J. Meikle, Esq.

Other Members of the Council.

P. C. Bose, Esq.

Mrs. Percy Brown.

J. C. Dutt, Esq., M.A., B.L.

H. B. Holmes, Esq.

F. W. Hawse, Esq.

A. T. Mitra, Esq., M.A.

J. C. Mitra, Esq., M.A., B.L.

Saroda Charan Mitter, Esq., M.A., B.L.

W. J. Simmons, Esq.

C. K. Sircar, Esq., C.E., M.S.A., M.S.E.

The Journal of the
Astronomical Society of India.

VOL. II.] SESSION 1911-1912. [NO. 2.

Proceedings of Monthly Meeting of the Astronomical Society of India held on Tuesday, the 28th November 1911.

MR. H. G. TOMKINS, C.I.E., F.R.A.S., *President*, in the Chair.

MR. P. N. MUKHERJI, M.A., F.S.S., } *Secretaries.*
MR. E. P. HARRISON, PH.D. }

The monthly meeting of the Astronomical Society of India was held in the Imperial Secretariat Buildings (ground floor) on Tuesday, the 28th November 1911.

The Proceedings were opened by the President, and the Minutes of the last meeting were confirmed.

The President then announced that the Council had considered a programme of work for the session and had decided—

(*a*) To institute a system of instruction of classes by post.

(*b*) To arrange for classes in elementary astronomy by means of lectures in Calcutta.

(*c*) To arrange for the systematic regulation of observations by those who possess instruments.

(*d*) To arrange for three public lectures in Calcutta during the session.

In order to work the details of these schemes, they had appointed a Scientific Committee in accordance with bye-law 42 and had also appointed Mr. B. N. Rakshit as Director of Classes and Mr. P. C. Bose as Secretary of the Committee and Director of the Meteoric Section.

The appointments were confirmed.

The Secretary then announced that the following presents had been received, and a hearty vote of thanks was awarded to the donors :—

1. Journal of the British Astronomical Association (Vol. XXII, No. 1).
2. Monthly Notices of the Royal Astronomical Society (Vol. LXXI, No. 9).
3. Rivista Di Astronomia of the Italian Astronomical Society (Anno V, Num. 11).
4. Monthly Weather Review of the Alipore Observatory for August 1911.
5. Journal of the Astronomical Society of Canada (Vol. V, No 5).

The President added that the Comptroller General had very kindly agreed to the telescope presented by Dr. Harrison to the Society being erected on the terrace of the Secretariat so that members might use it, and a vote of thanks was accorded to the Comptroller General with applause.

The following elections by the Council to the Society were then confirmed :—

1. G. C. Campbell Devon, Esq.
2. S. B. Buteni, Esq.
3. R. T. Greer, Esq., I.C.S., C.S.I.
4. P. N. Mukherji, Esq., M.A.
5. G. S. Apte, Esq., M.A., B.Sc.
6. F. D. Murad, Esq., M.Sc., B.A.

The first paper of the evening prepared by Messrs. C. K. Sircar and P. C. Bose on the Solar Eclipse was then read by Mr. Sircar, followed by some interesting lantern slide pictures on the screen which were duly explained by Mr. Sircar.

The President.—The method of taking the photographs I think consists of projecting the image on a screen and then photographing it. Of course in all these photographs you hold the camera in your hand.

Dr. Harrison.—Are these negatives or positives ?

The President.—Positives.

Dr. Harrison.—He did not get reversals ; did he ?

The President.—Oh ! no. I do not think the projected image would be strong enough for that.

The President, after inviting discussion on the paper, remarked that for the first paper of the session what had struck him during Mr. Sircar's reading was the thoroughness and systematic way in which Mr. Sircar and Mr. Bose had gone into the programme of their operations and then prepared their subject in minute details. The experience would be of great use and stand in good stead to the Society in their work during the coming season.

A hearty vote of thanks was duly accorded Mr. Sircar and Mr. Bose.

The next paper of the evening was contributed by Mr. Hart on the Movements of the Planets. Mr. Hart had already helped the Society with a similar diagram during last session for the Journal. The paper was kindly read by Dr. Harrison and followed by the Chart on the screen.

A vote of thanks was duly recorded to Mr. Hart.

The President then showed a Map of the Moon on the screen kindly sent in by the Revd. J. Mitchell, the first Director of the Lunar Section of the Society, which though unaccompanied by a paper proved of great interest. It was explained that the Council hoped to publish the maps in similar lines to the Star Charts last year. A hearty vote of thanks was duly returned to Mr. Mitchell for the trouble and pains he had taken to prepare the Map.

Dr. Harrison then read a paper kindly sent in by Mr. Evershed on a meteor which he had observed.

After inviting discussion on the subject, the President remarked that the Society had made another step in its progress in its meteoric work, inasmuch as in this case Mr. Evershed had succeeded in getting two observations and had also been able to calculate the height of the meteor and also follow its course. As regards the hissing sound, the President remark that it is not uncommon for the observer to hear such a hissing sound following the course of the meteor. The President added that there was just a possibility that the Maharaja of Jalawar, who had been very energetic in the Meteoric Section and had sent the Society three very valuable specimens found by him last season, might be able to be present at one of the future meetings of the Society.

With reference to the specimens sent in by the Maharaja, Dr. Harrison remarked that beyond testing the magnetic qualities of the meteor nothing further had yet been done, but steps were being taken to find the density, which was, however, a very difficult matter as the pieces could not be put into water or any other liquid. He hoped, however, to be able to accomplish this shortly as soon as the instrument at the Presidency College had been repaired as it had lately badly broken, and to report in a week or two. He was also taking steps to have one of the pieces analysed.

In calling for a vote of thanks to Mr. Evershed, the President remarked that Mr. Evershed's contribution was an interesting one in every way both as a contribution from himself, a professional astronomer, to the Journal and also as a record of a very interesting observation. The President also called attention to the fact that the path of the meteor in this case too was not a straight line but zig-zag.

Mrs. Voigt.—Surely there must be an explanation of this, and we might refer the matter to one of the Home Societies.

The President.—Yes, I see no reason why this should not be done. I think the idea a good one and would ask our Secretary to please make a note of it.

A vote of thanks was accorded to Mr. Evershed for his interesting contribution. A paper was next read by Mr. Banerji on Brook's Comet, followed by some lantern slide pictures on the screen.

This was followed by a letter from Mr. Evershed, read by Dr. Harrison, forwarding three very beautiful photographs of the same Comet, which were thrown on the screen; two photos being of Brook's Comet and one of its spectrum.

Mrs. Voigt.—Is this the first appearance of this Comet?

The President.—Yes, it was discovered on the 21st of July; though Mr. Brook has discovered others, I think this is the first appearance of this one.

Mrs. Voigt.—What constellations has it been in?

The President.—Do you mean on the 27th of October?

The paper contributed by Mr. Banerji was here re-read by Mr. Rakshit who explained this point.

The President.—I gather you think these three stars are in Lyrœ? It would be rather interesting to see just about where the Comet was in Mr. Banerji's slide, and I will, therefore, put it on again.

It appeared that by a coincidence one of the positions of the Comet given by Mr. Banerji in his paper was dated the 27th October, the date of the photograph.

In asking for a vote of thanks to be returned to Mr. Banerji and Mr. Evershed, the President remarked that in Mr. Banerji's paper one had a piece of work which was not always as very interesting, namely the getting together of a large number of different peoples' observations for an object like this which was seen all over the world and reported on in various Journals. This was no light task. Mr. Banerji had taken the trouble to wade through innumerable Journals, etc., and as a result had read his interesting paper that evening in which he had ably summarized the observations, and the fortunate arrival of the slides on this same subject so kindly sent in by Mr. Evershed made the paper more interesting then ever.

A vote of thanks was then accorded to Mr. Banerji for his paper and to Mr. Evershed for his beautiful slides.

Dr. Harrison then read a few extracts from a paper on the Eclipse of the Sun by Mr. J. C. Ray.

The President.—May I ask Mr. Bose if he can bear out the statement about the lunar prominences? I think he observed them.

Mr. Bose.—Yes, I made a calculation of the prominences and found them to be about elevations of about 36,000 feet.

The President.—Did you take into account in your measurements of magnification of the image on your screen?

Mr. Bose.—Yes.

After a vote of thanks to Dr. Harrison, the President adjourned the meeting to Thursday, the 21st December, this date being fixed on account of the Christmas holidays, instead of the last Tuesday in the month as usual.

NOTES.—With reference to the zig-zag appearance of the meteor trail, it may be of interest to mention that while at Delhi I was able to witness the day-light fireworks. These consist of rockets which leave behind them a trail of visible smoke, and in the same way the balls, etc., when the rockets burst, leave long trains of coloured smoke behind them. In every case these trains presented a zig-zag appearance exactly as in the case of the meteor which persisted for a short time. I think there is no doubt that it is due merely to light air currents which break up the straight streak at first left. H. G. TOMKINS.

Partial Eclipse of Sun seen from Calcutta on the 22nd October 1911.

By P. C. Bose and C. K. Sarkar.

On Sunday, the 22nd of October 1911, occurred the last Solar Eclipse to observe which we formed a party under the guidance of Mr. B. M. Rakshit. There were four men in the party. Mr. P. C. Bose and myself were mainly engaged on observing the time. Mr. K. D. Pal, an amateur photographer, in taking photos. Mr. Rakshit took down notes and generally gave us directions about all details.

The observations were made from the roof of premises No. 77-3, Musjeed Baree Street, in the northern quarter of the town of Calcutta.

The eclipse, as I have already observed, occurred on a Sunday and was considered to be of special significance to the Hindus. A Solar Eclipse on a Sunday or a lunar one on Monday constitute what is called a Chudamoni Yoga and is said to occur but rarely.

Messrs. B. M. Rakshit and A. Mitter of our Society had already made elaborate calculations and gave us the time when the eclipse was to begin.

The instruments at our disposal were a refracting telescope made by Mr. P. C. Bose of 2″·4 aperture with a magnifying power of about 60, a photographic camera by Messrs. Thornton and Picard, and two ordinary watches which were known to be very reliable time-keepers. The watches had been compared the same morning with the morning gun and with the chronometer at Alipur the previous day and were found to be keeping good time.

As a sort of preliminary training Mr. Rakshit wanted us to take photos of the Sun two days before the eclipse, to enable each operator to learn his part of work. A few photos were taken, but the result was far from satisfactory.

A few minutes before the expected time we were looking at the disc of the Sun—Mr. Bose through two smoked pieces of glass and I through the dark glasses of a Hadley's sextant. As we observed the first contact we called out time and the time was noted by two observers. The first contact was observed at 7-26 A.M. The computed time was 7h. 25m. 28s., the difference being half a minute only which was undoubtedly due to our observing the contact without the help of any instrument.

The arrangement for taking photos was made in a room on the second floor. To the iron bars in one of the windows of the room was tied a long wooden stick across the bars, and the telescope was tied on to it. A thick black curtain was used to cover up the window opening, leaving the object glass outside the curtain. A sheet of paper of dull white colour was pasted on to a sheet of glass in a picture frame. This was the screen we improvised on which the image of the Sun was thrown. The image was observed to be very distinct and sharp, and of this photos were taken. The screen was placed at right angles to the direction of the telescope as far as could be judged with our eyes. As the Sun was going up, the telescope had to be tilted up and the position of the screen shifted to obtain a clear round image of the Sun.

The plates used were Wellington extra speedy. Altogether 14 plates were exposed, but some of the plates were unfortunately spoilt in developing. As each plate was exposed the photographer of the party called out time and the two observers noted down the time observed by them. During the interval of taking photos the first two plates were developed immediately after they were exposed and they seemed to have been slightly under-exposed. The exposure given was $\frac{1}{40}$th part of a second which was subsequently increased to $\frac{1}{10}$th part of a second. The result was far more satisfactory. We tried time exposure with one of the plates, but the edge of the image was blurred. Apprehending that the photos might not turn out good it was decided to take traces of the images from the screen. A sheet of foolscap paper was placed on the screen and we attempted to sketch out the disc of the Sun and the shadow. This was found to be extremely difficult, as before the drawing of one part could be completed the image was observed to have shifted its position very considerably. I then thought of noting down the points of intersection of the bright and shadowed parts of the Sun and also a few points on the edge of the images. The circles were afterwards completed from the points noted on the circumferences. The sketches I now show give the exact sizes of the images of which photos were taken.

Nothing peculiar was observed on the disc of the Sun except that during the entire period of eclipse there appeared a sort of wavering of the shadow cast on the image of the Sun. This action seemed to be very great at 7-52 A.M. At 9-30 A.M. this motion was very much less, but was again observed to increase at 9-50 A.M.

At 8-58 A.M. we observed for the first time what appeared to be lunar prominences. These appeared distinctly till about

9-9 A.M. and were found to occupy the position shown on the sketch. The images of these measured between $\frac{1}{40}$th and $\frac{1}{20}$th of an inch, which compared to the diameter of the image of the Moon gave a height of more than 36,000 feet.

The atmosphere was generally clear during the period of observation, but on certain occasions light clouds were found floating across the disc of the Sun.

The last photo was taken at 9-57 A.M. The last contact, as observed independently by two observers from the image of the Sun on the screen, was 10h. 2¼m. which agreed with the computed time.

The last photo was taken at 9-57 A.M.

A Great Meteor.

BY J. EVERSHED, F.R.A.S.

A large meteor or aerolite was seen at Kodaikanal on October 25 at 6 hrs. 53 mins. P.M. Indian Standard Time, by one of the assistants of the Observatory, Mr. Subramania Aiyar, who was able to make some definite observations of the phenomenon. He states that he first heard a hissing noise like a cracker hissing on water, and on looking up saw an intense blue spherical glow of light followed by long sparks of a yellowish-red colour. The fireball was first seen about 10° west of the zenith and a little north, and it travelled to about 35° east of the zenith and a little south. The sparks of the tail were not distributed in a straight line but appeared to follow a zig-zag course ; the head appeared to become brightest at the end of its course just before it disappeared, and the whole phenomenon lasted about 5 seconds. The evening was rather cloudy with distant thunder.

In addition to the above account I have received a description of the meteor as seen at Coonoor, a hill station in the Nilgiris, about 90 miles north-west from Kodaikanal. Miss M. C. Feline of the Hebron school was walking eastwards along a road much shaded by large trees, her view of the meteor was in consequence much impeded ; but she was able to determine its probable path by reference to certain landmarks. Apparently no stars were seen at the time, but Miss Feline on subsequent evenings carefully determined the directions of the landmarks from the positions of well-known

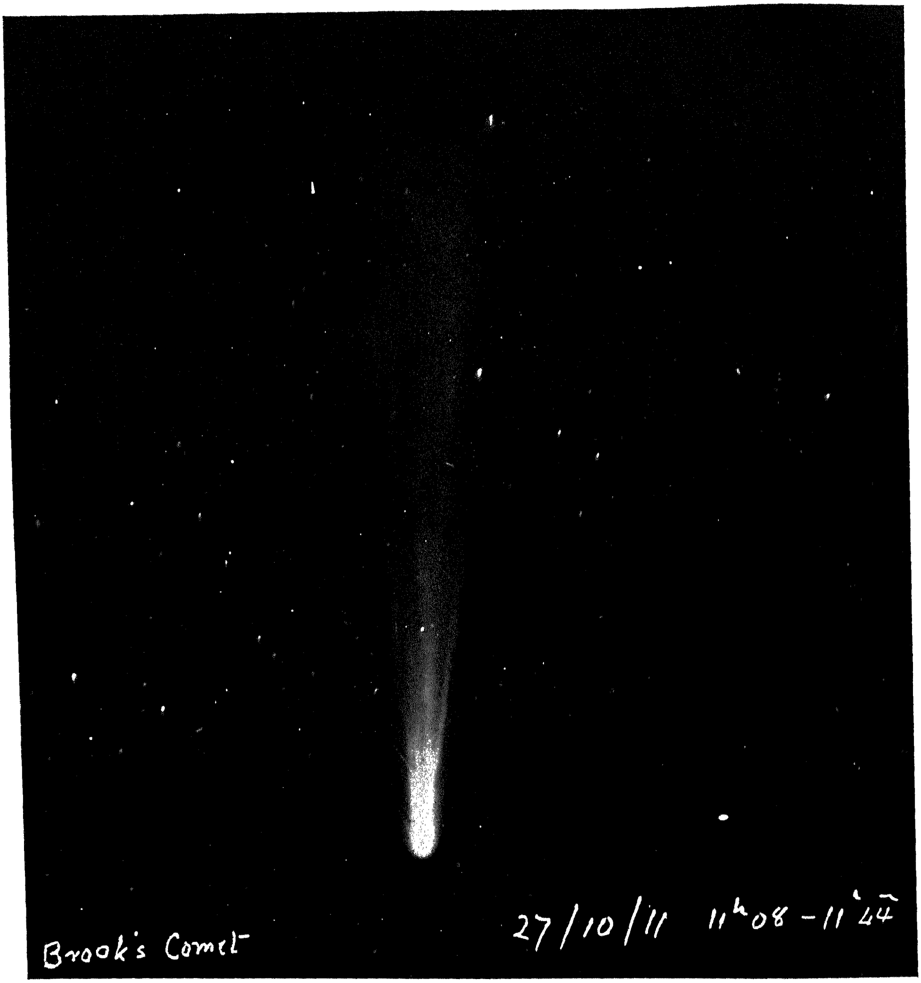


Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1912.

Photograph of Brook's Comet

taken by Mr. J. Evershed, at the Kodai Kanal Observatory, on October, the 27th, 1911.

stars, and was thus enabled to give the approximate altitudes and azimuths of the meteor when first seen and also at the end of its course. She heard no noise, but was first made aware of the meteor by an intense light falling on the ground in front of her, and from the movement of this light she inferred that the meteor must have travelled from the west towards south. When she looked up it was about south at an altitude of 60°. It then moved down towards the south-east ending at about 30° above the horizon.

If the altitude of the end point is not greatly over-estimated the actual height of the meteor above the earth at disappearance would be over 70 miles, and its distance from Kodaikanal nearly 90 miles. If any sound could have been heard at this distance, it would not have been perceived until 7 minutes had elapsed after the meteor had disappeared; it is probable, therefore, that Mr. Subramania was mistaken in supposing the sound he heard was due to the passage of the meteor.

The observations are not precise enough to give the radiant point of the meteor with any certainty; all that can be inferred is that it must have been in the western or north-western sky, perhaps not very far from the constellation Ophiuchus.

Note on Brooks' new Comet c 1911.

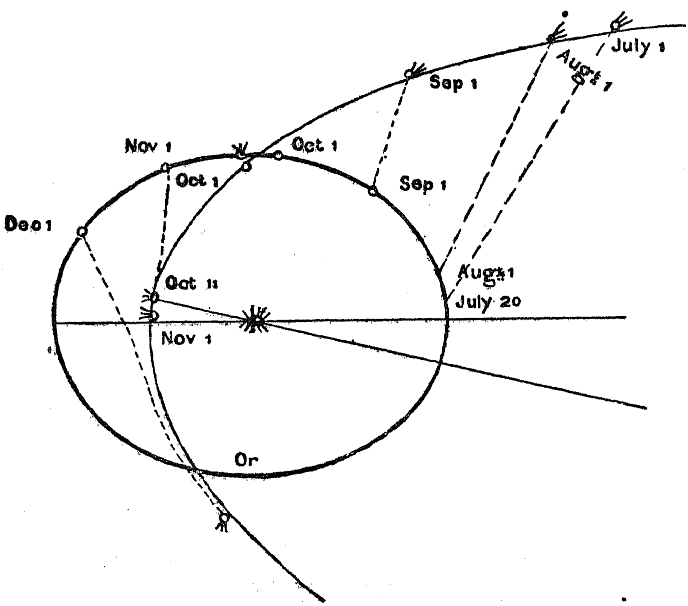
BY U. L. BANERJEE.

There has been a great stir in the astronomical world by the announcement that on the night of July 20, Professor Brooks of the Smith Observatory, Geneva, discovered a new Comet on the eastern heavens. Its position at 15 hour G. M. T. on that day was R. A. 22h. 13m. 40s. and declination N. 20° 57′, which placed it on the western side of the constellation Pegasus. It was then moving slowly northward.

Several observations have since been taken of this new Comet by different astronomers at different parts of the world and their results are summarised below. They have been arranged chronologically to give an idea of its progress round the Sun, its development from a feebly nebulous state into a strong nucleus, and the growth of its tail.

For better understanding the different phases of this Comet from the date of its discovery to the present date, I

reproduce below a diagram showing the orbits of the Comet in relation to that of the Earth, drawn from the elements computed by Mr. Young and Miss Aitken of the Lich Observatory :—



The paths of the Earth and the Comet approached each other until about Oct. 1, after which the Comet's rapid movement carried it quickly away, but during the month of October it approached the Sun and consequently got brighter and brighter all the time, making it quite visible to the naked eye.

July 25.—Mr. F. C. Leonard, President, Society for Practical Astronomy, Berlamont, noticed it as a faint hazy object, and took it for a very condensed nebulous star cluster, hardly distinguishable on a nebulous background. It was approximately circular and about 3′ to 3′-30″ in diameter, being very diffuse near the edges and appearing like a nebula or Comet with a stellar nucleus.

July 26, 27.—It moved towards Pegasi, with its centre more condensed showing indications of a stellar nucleus.

August 4.—Mr. Harold Thomson, New-castle-on-Tyne, noticed it as a nebulous patch of light with possibly a faint stellar nucleus, but could not detect any tail.

August 6, 7, 8.—Observations made at Berlamont with 3 inch. Telescope showed signs of a tail.

August 11.—Mr. F. W. Longbottom of Queen's Park, Chester, found the Comet steadily developing, the stellar nucleus now quite equalling mag. 6, the comma growing to an elliptical nebulosity some 4′-30″ along its major axis. An eccentrically placed straight tail extended over 1 degree towards the south.

August 15.—It was just barely visible to the naked eye, and Mr. W. F. Denning found it much brighter since.

August 17.—Observations taken at Chicago showed that it had passed from the constellation Pegasus into Cygms and gains sufficient brightness.

August 18.—Both Messrs. Longbottom and F. W. Barlow observed it by the naked eye. There was a distinct stellar nucleus which was not distinctly visible on account of the general increase in brilliancy towards the centre. The whole appeared to be somewhat elliptical, but no tail could be traced.

August 24.—Mr. F. W. Longbottom took photograph of the Comet and noticed a second tail, which he, however, ascribed possibly to the defect in the exposure.

Mr. F. C. Leonard of Leonard Observatory, Chicago, however, noticed a marked condensation to a nucleus. A fair number of stars could be seen shining right through the body of the Comet. It was circular, but there was no indication of a tail. It filled a large part of the field of view, and the matter the Comet extended from it a long distance in every direction.

August 26.—Mr. Leonard noticed slight indications of a real tail.

August 28.—Mr. H. H. Walters of Liverpool found it growing rapidly brighter and bidding fair to become a very interesting object. Its brightness was estimated as very nearly equal to the Andromada nebula. The photographs taken by him showed a small bright nucleus surrounded by an oval nebulosity.

August 29.—Mr. Leonard observed the Comet by the naked eye as a nebulous spot and detected a small tail.

August 31.—He found the Comet much more condensed and its nucleus condensation very obvious. An almost stellar nucleus developed, which was placed in the centre of the head. There were indications of a tail, and the Comet moved a fair distance during the observation. Its estimated diameter appeared to Mr. Alfred 6′ to 8′.

September 1.—The Comet was distinctly visible to the naked eye. Upon close study Mr. Leonard found it to be

generally fan-shaped, and possibly one or two small stars near by were visible through the tail, which in some respects appeared to be double, consisting of two parts separated by a small distance of very faint haze. The nucleus and matter appeared very condensed.

Mr. Alfred found the estimated diameter 10′ fully equal to 4 degree mag. stars in light. The margin appeared to him to be very diffuse.

September 2.—From a photograph taken by Professor Bernard of Yerkes Observatory, he found that the head of the Comet was nearly 510,000 miles in diameter, and the tail had an extent of about 8 degrees apparently equivalent to 10,000,000 miles. Because of its position in its orbit, this vast extent of the tail was not apparent, since it was inclined towards the Earth and was therefore foreshortened by perspective.

September 3.—Mr. Alfred found the diameter 12′ at least, but very faint near the margin.

September 4.—It was running north-west from the contellation Cygnus towards the constellation Draco.

September 15.—Mr. A. G. Black found the Comet very bright and about 12′ in diameter. The nucleus was distinct but not stellar. The magnitude was about 4.

Mr. Alfred also observed it on that very night and found its tail about 80′ and perhaps more. Centre of its head was much brighter. It seemed increasing rapidly in brightness, but not much in diameter.

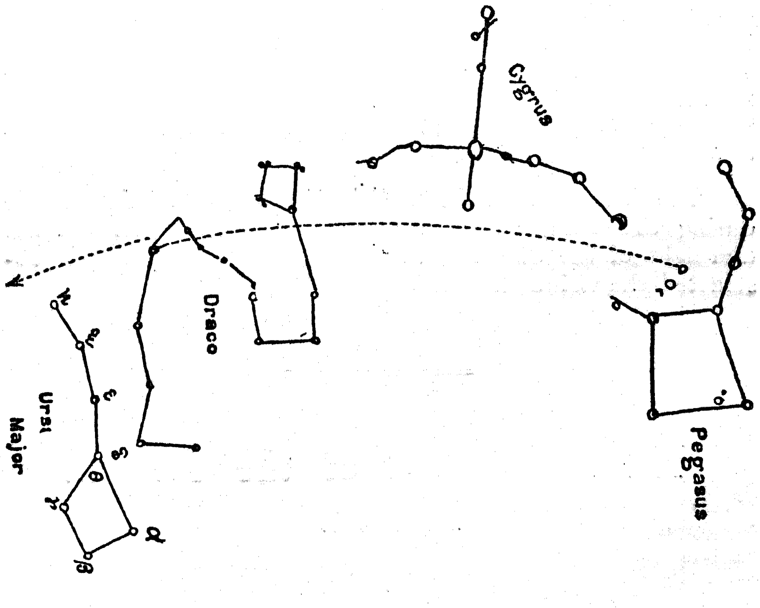
September 16.—Mr. S. E. Percival of Meniot noticed the coma condensed to the nucleus, which shone with the appearance of frosted silver reflecting a soft light. A small star was shining through it in the lower part. A distinctly streaked slight tail of about 4 degrees in length and ½ degree in diameter was visible. It was better seen by getting the coma just out of field. He also observed the Comet spectroscopically and saw three distinct bright bands of comeling spectra, the middle one was decidedly the brightest, and each of these bands was sharp towards the red ends and shaded off towards the violet. No continuous spectrum was visible.

September 24.—Observations were taken on this night by Messrs. N. K. Johnson of Canterbury and R. H. Butcher of Derby Road, Ansdell Lytham. The former found the tail about 2 degrees long by naked eye and 9 degrees by a binocular, standing vertically up from the coma. The tail was brighter at the centre than the edges. The nucleus was

not in the centre of the coma, but displaced in the direction of motion. Mr. Butcher could trace the tail for about 6 degrees. The comet closely resembled Halley's Comet, as viewed from South Africa, a few days after Periheteon Passage. It was bluish green in colour, while Halley's was rich golden yellow.

September 30.—Mr. M. B. Heath of Kingsbridge, S. Devon, had an excellent view of the Comet. With the naked eye the coma was of course obvious, and by careful observation several degrees of the tail could be seen; and by a binocular, the tail seemed 6 degrees in length, standing almost perpendicular to the horizon, but slightly inclined to the west. The telescope showed a bright nucleus, not stellar, surrounded by dense nebulosity, with a decided though faint tail, extending considerably beyond the length of the field. One star was visible through the tail.

Below is given a rough sketch, showing the path of the Comet from the west on July 20, the date of its discovery by Professor Brooks to the west of Ursa Major in the beginning of October:—



October 4.—Mr. Leonard located the Comet a short distance south-west of N Ursa Majoris. Viewed through an opera

glass the head of the Comet was very apparent and bright and the tail was visible for a considerable distance; through a telescope the nucleus appeared well defined, head better developed, the tail much brighter, especially near the head and wider in proportion to the latter. The nucleus appeared to be somewhat yellowish in colour.

October 12.—Very beautiful; the nucleus light greenish yellow in colour.

October 25.—Mr. C. Groves of Ronerdan Observatory found it a truly splendid naked eye object. The nucleus was quite bright and the long straight tail pointing nearly vertical, fully 20 degrees in length.

October 27, 28, 29.—Observed on three successive nights, it appeared very conspicuous, although suffering greatly with the glittering effulgence of the Venus. On 28th it appeared one of unexpected and unrivalled beauty, with a bright nucleus and a tail about equally bright and absolutely perpendicular. Seen through a field glass, one-third of the tail seemed to be as bright as the nucleus itself, verging away gradually and imperfectly into a dimmer yellow.

November 2, 3, 4.—Observed at Calcutta by the naked eye, the coma with the bright nucleus was distinctly visible. The tail extended to a great distance and through which some stars could be seen. The light of the Venus almost dimmed the tail to a certain extent, but obstructing the Venus, by means of the hand, the tail could be traced to a considerable distance from the coma.

The observations from Calcutta were not favourable during the summer nights, as the moonlight obstructed the dim light of the Comet, and latterly the moving clouds obstructed the vision altogether.

The Movements of the Planets in 1912.

BY H. HART.

The accompanying diagram will show the heliocentric positions of the planets on the day in each month on which

the Sun enters the different signs of the Zodiac : *i.e.*, on January 21 (Aquarius), February 22 (Pisces), March 20 (Aries), April 19 (Taurus), May 20 (Gemini), June 21 (Cancer), July 22 (Leo), August 22 (Virgo), September 22 (Libra), October 23 (Scorpio), November 22 (Sagittarius), December 21 (Capricornus). The positions on intervening days can easily be calculated ; the dots between the Earth's positions representing intervals of five days.

Mercury is a morning star until March 2, when he is in superior conjunction with the Sun. An evening star thence until April 15 when in inferior conjunction, a morning star until June 17, an evening star until August 21, a morning star until October 3, an evening star until December 8, and a morning star for the rest of the year.

Venus is a morning star until July 5, when she becomes in superior conjunction with the Sun and is an evening star for the rest of the year.

Mars continues as an evening star until November 4, when he is in conjunction with the Sun; and thereafter a morning star for the rest of the year. He is in quadrature with the Sun on March 4.

Jupiter is a morning star until May 31 when he becomes in opposition to the Sun. An evening star thence until December 18, when he is in conjunction, and a morning star for the rest of the year. He is in quadrature on March 4 and August 30.

Saturn is in evening star until May 14, when he becomes in conjunction with the Sun ; thereafter a morning star until November 22, when he is in opposition ; and an evening star for the rest of the year. He is in quadrature on August 26.

Uranus is in conjunction with the Sun on January 20, in quadrature on April 21, in opposition on July 24, and in quadrature on October 22. He covers only 4¼ degrees of his orbit during the year.

Neptune covers only 2¼ degrees of his orbit in the year. He is in opposition on January 13, in quadrature on April 10, in conjunction on July 15, and in quadrature on October 19.

The diagram will show that when looking from the Earth towards the Sun on any date, the planets on the left hand are evening stars, and those on the right hand are morning stars. Thus, on March 20, Mercury, Mars, Saturn and Neptune are evening stars ; and Venus, Jupiter and Uranus are morning stars.

Astronomical Notes.

BY. J. C. ROY, F.R.A.S.

The reference by the President to pin-hole photography of an eclipsed sun (Journal for July) reminds me of a curious photo-micrographic experiment with which I once tried to secure the same result. In 1898, January 22, there was the record total solar eclipse observed from India within the recent times. I had calculated the phases of the eclipse and desired to take a photograph in order to check, if possible, my calculations. I set up a telescope in a garden which was unfortunately not in a secluded part of the town. The eclipse, though not total from the town, excited a great deal of curiosity among the people, and I was soon besieged by a large number of friends and other on-lookers. The result was that I had to give up the telescope to them. Feeling disappointed and having nothing to do in the sun, I took shelter in my laboratory where a microscope caught my eye and led me to use it in place of the telescope. A looking glass placed outside sent an image of the eclipsed sun into the room. The beam of light was passed through a converging bus placed at such a distance from the microscope that an image of the sun was formed at the stage. The minute image was treated as a microscopic object and magnified by a 1″ objective. The eye-piece was removed and a camera was pushed into the end of the microscope tube. I think I used a ground glass screen to cut off a portion of the illumination and tried to give as short an exposure as I could with the hand. The negative, however, brought out a positive picture of the eclipsed sun (as will be seen from the photograph). The experiment, though not of much practical value, was amusing.

The October solar eclipse was observed here along with three computers of three different Oria almanacs in use in Orissa for the purpose of verifying the times calculated by them. It is well known that purely Indian almanacs are seldom correct in these times. So was the case on this occasion too. The observed times for the beginning and end of the eclipse were 7 hrs. 4 mins. and 9 hrs. 30½ mins. (St. T.) respectively. The only almanac which gave times nearer to these was the one computed after the *Siddhânta-Darpana* by the son of the late author. The times given were about 4 mins. too early. This near approach is, I believe, accidental. The eclipse chart reproduced in the Journal has been found useful. It has, however, to be borne in mind that an unaided eye is generally one minute too slow in noticing the first contact and one minute too fast in seeing the last contact.

The contacts were observed through a binocular (mag. ×8) and the watch used was corrected by means of a sun-dial.

Solar eclipses have another value. It is on these occasions that people at all gaze at the sun, though of course through coloured glasses. If large sun spots happen to be present at the time, they are seen with the naked eye. The partial obscuration of the sun helps to some extent in picking up the spots. There are, however, other times when the spots, if large, become visible to the naked eye. The best time is perhaps a few minutes before sunset. The last occasion, when this happened, and of which I have a record, was on the 22nd April of the last year, *i.e.*, two days after the perihelion passage of Halley's comet. I was looking for the reappearance of the comet just before sunset, when the spot, which was not of extraordinary dimensions, was noticed by some friends who had not previously seen any.

The atmospheric condition in Calcutta is perhaps not favourable for these naked-eye observations. For I could never see the Zodiacal light from Calcutta, while it is an almost every day phenomenon from these latitudes. Then again we saw for a week the rapidly moving comet of January 1910, while none seemed to have noticed it from Calcutta. It is quite a common thing for us here to see Venus at 11 A.M., and sometimes even at 11½ A.M. in strong day light.

Extracts from Publications.

The report of the Departmental Committee on the Solar Physics Observatory, now at South Kensington, is a divided one. Sir T. L. Heath, Mr. Dyson and Professor Schuster recommend that the solar physics work be transferred to Cambridge, with an initial grant for buildings and a fixed annual inclusive grant-in-aid to the University, provided that the University will agree to the following conditions:—(1) That the professor of astrophysics be the director of the solar observatory; (2) that there be a committee or syndicate nominated by the University with functions similar to those of the Board of Visitors of the Royal Observatory at Greenwich; (3) that the Astronomer Royal and the Director of the Meteorological Office be *ex-officio* members of the committee or syndicate; (4) that the University undertake to carry out at the new observatory the necessary amount of routine work on

the general lines indicated in paragraph 14 (*b*) and (*c*); (5) that an annual report, to include a statement of the work done and an abstract of the accounts of the solar observatory showing the application of the grant-in-aid, be presented by the Director to the committee or syndicate, to be by them transmitted to the Treasury. With a view to the permanence of any arrangement, the committee desire to point out the importance of attaching the directorship of the solar observatory, if established at Cambridge, to a professorship which is not merely of a temporary character. Dr. Glazebrook dissents from his colleagues. He says :—"I believe that the evidence placed before the committee and the facts detailed in the report lead to the conclusion that, on a balance of all considerations, a scheme for locating the observatory at Fosterdown........could be arranged at an annual cost of £3,000, with a capital outlay of £5,000, and would secure the best results."

It appears from an appendix that Sir Norman Lockyer, F.R.S., Director of the Solar Physics Observatory, is not in favour of the transference to Cambridge, and recommends the Fosterdown site.

[*English Mechanic.*

At the October meeting of the British Astronomical Association, the President gives an address on the progress, or otherwise, of the Association, with some remarks on any astronomical subject that he chooses, and Mr. Knobel, after congratulating the members on the new status of the Association, towards the accomplishment of which he himself has done so much, went on to talk of things astronomical, specially dwelling on the question of the application of the dry plate to certain lines of astronomical questions, a practical subject on which he is an expert. The Association evidently begins a new year full of life and vigour, as befits a body which has just attained its majority.

[*English Mechanic.*

The Astronomical Society of Barcelona.—Since receiving the Royal favour a year ago, this Society has considerably increased in numbers. The roll now contains 400 names and the Society is entering upon its second winter season with very rosy prospects. One of the objects of the Society, upon which special stress was laid at its foundation in January 1910, was the provision of a public observatory where members might meet on fine evenings to study celestial phenomena and to discuss points of astronomical interest. Senor Rafael Patxoty Jubert, one of Spain's illustrious men of science, and

a foundation member of the Society, has offered to present his observatory and instruments to the Society, and, needless to say, the offer has been eagerly accepted. This establishment, the Observatori Catala, is situated at San Felix de Guixols, in the province of Gerona, and in importance it stands next to the observatories of Madrid and San Fernando. It has accomplished much valuable astrophysical work under the directorship of its owner during the past ten years, chiefly in the direction of the measurement of multiple stars. The whole establishment will be removed immediately to Barcelona, where it will be re-erected on the roof of one of the public buildings in a position easy of access to all members of the Society. The dome, which is constructed of steel, has an internal diameter of 17 feet and was made by Messrs. Gilon of Paris. It covers a fine double equatorial by Mailhat, visual and photographic, with apertures of 8¾ inches and focal lengths of 10 feet and 7 feet 9 inches respectively. A complete set of accessories of precision is included in the gift-Spectroscope, micrometer, camera, electric pendulum and azimuthal theodolite. Annexed to the observatory in its new position will be a room for meetings of the Society, library, photographic laboratory, etc.

[*English Mechanic.*

Remarkable photographs of the Planet Mars have been taken by M. Tikhoff, states the Gazette of the Russian Observatory at Pulkowa. The superior definition of the new photographs is due to the use of improved plates and coloured screens, which have enabled the astronomer to obtain fine contrasts in his pictures. The best photographs of the "canals" of Mars were taken through red and orange screens, and from these, it is claimed, it would appear that the "canals" are filled with water, or at any rate, something which has a sea-green colour. Further studies of a similar kind in connection with the Polar Cap indicate that ice is present there, and not snow. M. Jarry-Desloges of the Massegros Observatory reports that the northern cap wears a bluish appearance and is particularly brilliant. Sometimes the cap can be traced to the fortieth degree of latitude, and at other times it is much more closely limited to the Polar regions.

[*English Mechanic.*

It is well known, remarks Mr. P. H. Ling, in *Nature*, that the aphelia of many comets are grouped at distances which are nearly the same as those of the larger planets, and astronomers have sometimes attempted to use this fact to demonstrate the existence of a planet beyond Neptune. M. Flammarion mentions two cases—a comet which appeared in 1532

and 1661, and Tuttle's 1862 comet, which is related to the Perseid Meteors, and has a period of 121½ years. These are taken as indications of a planet at a mean distance of about 48 astronomical units. The evidence is obviously insufficient, and special interest therefore attaches to the statement that the Kiess comet (1911*b*) is possibly the same as 1790 I. If the identity can be established, this comet must belong to the same group as the other two, and may be regarded as strengthening their evidence as to the hypothetical planet.

[*English Mechanic.*

With regard to the order of the planets, committing to memory the following sentence may assist some beginners :—

Many Very Excellent Men Joyfully Study Universal Nature.

Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune.

[*English Mechanic.*

The facts in the following newspaper cutting are essentially correct :—

A church spire has recently been saved from destruction in a very odd way. The Astronomer Royal was testing a telescope at the Observatory in Greenwich Park, and chose the spire of St. Johns' Church, Blackheath, a mile away, as a fixed object on which to focus the instrument. He was astonished to see a serious flaw in the stonework of the spire—there was a gaping fissure through which daylight appeared. The rector was informed, steeple-jacks went up, and the crack was found to be about fourteen feet in length. The church is closed and repairs are going on.

[*The Observatory.*

Celestial Photography with ordinary Portrait Lenses.—Perhaps the majority of students of Astronomy are of the opinion that, in order to make photographs of the heavens, the very finest of apparatus must be used. While it is conceded that of two cameras, the one specially made for celestial photography by eminent opticians will produce the best results, yet good pictures can be made with ordinary portrait lenses, which now-a-days may very often be purchased for a trifle at some of the older photographic studies throughout the country. The apparatus I have used in celestial photography is of the simplest possible construction, consisting of a square box of wood, painted black outside as well as inside, to which the lens, a Darlot of 3 inches aperture and of

10 inches focus, is securely fastened. This box is made in two sections, one sliding within the other, making it adjustable for focussing.

It is of no use trying to focus on the stars; the best way is to expose several plates until the star trails show as the finest lines. Most portrait lenses are lacking in a flat field, and it becomes necessary to compromise on the roundness of the field and focus sharply at a little distance from the centre, this will tend to make it sharpen all over, at the expense of the centre.

The camera is securely bolted to the telescope and carries an ordinary 4 × 5 Premo plate holder. The telescope is equatorially mounted and is moved by a simple tangent screw. The eyepiece is provided with cross wires, and when following a star, I put it slightly out of focus, so that it forms a disc, which may then be accurately bisected, and one of the wires is put parallel with the motion of the stars in the field of view.

[*Popular Astronomy.*

The difficulties in the way of saying at once that Mars is habitable by beings like ourselves are three—the lack of heat from the sun, the lack of atmosphere, and the lack of large bodies of water. Being 1·4 further from the sun, Mars receives only half the heat that the earth does, and this fact would argue that in the absence of a dense blanket of water vapour to retain the heat, the temperature must be extremely low, too low in fact for ice to melt at all. The change of the polar caps contradicts this, and those who argue for low temperature are forced to suggest some other substance than snow to account for the caps. Carbon dioxide has been suggested by some as a substance whose crystals are as white as those of snow, and whose temperature of crystallization is much lower than that of water. But Lowell points out that at pressures of anything like that of our atmosphere or less, carbon dioxide passes at once from the solid to the gaseous state. Water lingers in the intermediate state of a liquid. The Martian Cap as it melts is surrounded by a deep blue band, which accompanies it in its retreat, shrinking to keep pace with the diminution of the cap. This is what we should expect if it were water. And if we are to bring in an extra amount of carbon dioxide, a far less increase over the amount found in the earth's atmosphere would so add to the heat-retaining power of Mars' atmosphere as to account for the apparently high temperature indicated by the observed seasonal changes.

Of the rarity of the atmosphere there is no question. The mass of Mars is so much smaller than that of the earth that

the force of gravity at the surface of the planet is too weak to retain an atmosphere of anything like the density of our own. Even the most ardent advocates of the possibility of life on Mars admit that if one of us were to be suddenly transported to that planet, he would probably die in a few minutes because of the rarity of the atmosphere. But it is claimed that beings like ourselves might gradually become accustomed to an atmosphere much rarer than ours, and this is probably true. That water is comparatively scarce there, is also unquestioned. The spectroscopic observations of Mars at Flagstaff indicate very little, if any, absorption by water vapour, and those by Campbell at the summit of Mount Whitney show no trace of any at all. In fact, if Lowell be right, it is this very scarcity of water which has brought about the evidence which comes nearest to proving that there are actually living intelligent beings on Mars.

[*Popular Astronomy.*

Memoranda for Observers.

Standard time of India is adopted in these Memoranda.

For the Month of January 1912.

Sidereal time at 8 p.m.

			H.	M.	S.
January	1st	... ...	2	39	32
	8th	... ...	3	7	8
	15th	... ...	3	34	44
	22nd	... ...	4	2	20
	29th	... ...	4	29	56

From this table the constellations visible during the evenings of January can be ascertained by a reference to their position as given in a Star Atlas.

Phases of the Moon.

				H.	M.	
January	4th	Full Moon	... ...	7	0	P.M.
	11th	Last Quarter	... ...	1	13	,,
	19th	New Moon	... ...	4	40	,,
	27th	First Quarter	... ...	2	21	,,

Meteors.

There is one important shower in January—the Böotids of 2nd and 3rd.

Radiant Point.		Character.
R. A.	Dec.	Swift, long paths.
15h. 20m.	+53°	

Other showers occur on 3rd, 11th, 17th, 17th—23rd, 25th and 29th January.

Planets.

Venus—Is a morning star. Its position on the 15th January at 8 P.M. will be R. A. 16h. 46m. 34s., Dec. 20° 12′ 35″ S. The time of its rising will be 3h. 21m. A.M. on the 16th January.

Mars.—The position of this planet on the 15th January at 8 P.M. will be R. A. 3h. 32m. 29s., Dec. 21° 28′ 51″ N. The time of its setting will be 2h. 13m. A.M. on 16th January.

Jupiter.—The position of this planet on the 15th January at 8 P.M. will be R. A. 16h. 22m. 45s., Dec. 20° 48′ 37″ S. The time of its rising will be 2h. 57m. A.M. on the 16th January.

Saturn.—The position of this planet on the 15th January at 8 P.M. will be R. A. 2h. 46m. 17s., Dec. 13° 37′ 5″ N. The time of its setting will be 1h. 12m. A.M. on the 16th January.

Notices of the Society.

Election of Members.

The attention of members is invited to Bye-Law No. 14, regulating the election of persons who desire to join the Society. It is hoped that those who are already members will induce others to join. Forms of application can be had from the Secretary, Mr. P. N. Mukherji.

The Library.

A subscription list exists and several members in Calcutta have subscribed and enabled the Council to make a beginning with the Library. Other members outside Calcutta, however, have not except in one or two cases yet come forward, and as the Library will be one of the most important adjuncts of the Society, and will be available to members both in and out of Calcutta, those who have not yet done so are invited

to help the Society in making progress with this important branch of the work. Suggestions as to useful books for the Library will also be welcomed by the Librarian.

A number of books have already been received and can be borrowed by members in accordance with the Bye-Laws.

The books available can be ascertained from the Assistant Librarian and a catalogue will be issued shortly. The reading room of the Society in the Imperial Secretariat is now opened for the use of members daily from 5 to 7 P.M. except on Wednesdays and holidays and from 3 to 5 P.M. on Saturdays unless that day is a holiday.

Subscriptions.

Subscriptions for the current session fell due on 1st October 1911. Those who have not paid in their subscriptions are requested to remit them to the Treasurer at their convenience.

Papers for Meetings.

It is requested that drawings which accompany papers for reproduction in the Journal may be made with Indian ink on white paper. This will insure a clear reproduction.

List of Instruments.

With a view to enable the Council to obtain a knowledge of the instrumental equipment of the members, it is requested that those members who possess any instrument suitable for Astronomical work will kindly send details to Director of Instruments of its kind, size and power.

Programme of work for the Session.

Sub-Committee.—The Council have appointed a Scientific Sub-Committee consisting of the Scientific Secretary and the Directors of Sections. This Sub-Committee will direct the observational and educational work of the Society under the Council, and will consider in detail and take steps to introduce practical work. To begin with, the following are to be considered are taken up :—

(*a*) Instructions and classes for members who are beginners.

(*b*) Observational work for those members who will embark on it.

(*c*) Practical classes for members in Calcutta.

(*d*) Public lectures in Calcutta.

Members will shortly receive communications from the Sub-Committee regarding these matters.

Meetings for the Session 1911-12.

ORDINARY MEETINGS.

1912.	1912.
January 30th.	April 30th.
February 27th.	May 28th.
March 26th.	June 25th.

The Meetings will commence at 5 P.M. and, until further notice, will be held in the Imperial Secretariat (Treasury) Buildings.

Addresses of Officers.

Owing to inconvenience which has arisen from addressing the Officers of the Society at their private address, it has been decided to receive communications on the business of the Society in future as follows:—

	To
Money Orders or letters containing money or cheques.	U. L. BANERJEE, ESQ., Office of the Accountant-General, Bengal, 3, Koila Ghat Street, CALCUTTA.
All other communications	*(Name)* ....Esq. *(Designation)* ....of the Astronomical Society of India, Imperial Secretariat (Treasury) Buildings, Calcutta.

It is requested that communications may be addressed accordingly.

Officers and Councils.

FOR THE SESSION 1911-12.

(1) *President* . . .	H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.
(2) *Vice-Presidents* . .	(1) COL. S. G. BURRARD, R.E., C.S.I., F.R.S.
	(2) J. EVERSHED, ESQ., F.R.A.S.
	(3) SREE RAJA A. V. JUGGA RAO BAHADUR GARU, F.R.A.S., F.A.I., F.R.M.S., F.A.S. & C.
	(4) H. H. THE MAHARAJA RANA BAHADUR SIR BHAWANI SINGH, K.C.S.I., F.R.A.S.
(3) *Secretary (Scientific)*	DR. E. P. HARRISON, PH.D.
Do. (Business)	P. N. MUKHERJI, ESQ., M.A., F.R.E.S., F.S.S.
Treasurer . .	U. L. BANERJEE, ESQ., M.A.
Directors of Sections—	
Lunar Section .	H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.
Meteor Section .	B. N. RAKSHIT, ESQ., B.A.
Variable Star Section	LIEUT.-COL. LENOX-CONYNGHAM, R.E., F.R.A.S.
Instrumental Director	S. WOODHOUSE, ESQ.
Librarian .	C. T. LETTON, ESQ.
Editor .	J. J. MEIKLE, ESQ.

OTHER MEMBERS OF THE COUNCIL.

P. C. BOSE, ESQ.
MRS. PERCY BROWN.
J. C. DUTT, ESQ., M.A., B.L.
H. B. HOLMES, ESQ.
F. W. HOWSE, ESQ.
A. T. MITRA, ESQ., M.A.
J. C. MITRA, ESQ., M.A., B.L.
SARODA CHARAN MITTER, ESQ., M.A., B.L.
W. J. SIMMONS, ESQ.
C. K. SIRCAR, ESQ., C.E., M.S.A., M.S.E.

The Journal of the
Astronomical Society of India.

VOL. II.] SESSION 1911-1912. [No. 3.

Report of Monthly Meeting of the Astronomical Society of India held on Thursday, the 21st December 1911.

MR. H. G. TOMKINS, C.I.E., F.R.A.S., *President*, in the Chair.

The Monthly Meeting of the Astronomical Society of India was held in the Imperial Secretariat Buildings (ground floor), on Thursday, the 21st December 1911, at 5 P.M.

The Proceedings were opened by the President and the Minutes of the previous Meeting confirmed.

The first paper of the evening was read by Mr. P. C. Bose on Meteors.

The President.—Perhaps it will be convenient, before I open Mr. Bose's paper to discussion, to mention that I notice in the first part of his paper Mr. Bose puts down the origin of meteors to collisions. The next point which struck me in his paper was the destruction of orbits. The third point I noticed was the collision of meteors with comets. I would ask discussion on these points. Professor Bickerton has dealt with collisions of stars, but I do not know that the collision of two meteors would produce a shower of bright meteors. Professor Bickerton thinks that the collision of two stars would produce a third star somewhat in the manner which I will illustrate on the board (drawing on the blackboard). The part in

the middle where they graze, he holds, would liquefy and form a third body, and the parts which do not touch still go on in their course as stars. But the theory is not generally accepted as accounting for the brightening up of the new stars, which we sometimes see in the heavens. I think it more likely that a comet breaking up may account for the meteors, and this has some support from observation. In connection with this I would draw attention to the shower of 23rd November. As regards the Leonid shower, the reason why those meteors have not appeared again is that the orbit has been shifted on to another course, and consequently we do not see the shower. At least many consider this a reasonable explanation. I do not think that it was intended that these meteors should fall into the centre of that. Mr. Bose is in good company, as Dr. Sil, in the book which has just been published, considers bombardments by meteors likely.

A hearty vote of thanks was duly accorded to Mr. Bose.

The next paper was read by Dr. Harrison on "Inorganic Evolution," which he illustrated and explained by several interesting drawings on the blackboard.

The President.—There is one point on which I should like to ask a question, and that is: when you have two stars of the same brightness, how is it possible to know that one is rising and the other falling in temperature?

Mr. Meares.—Is there any relation between colour and temperature? Are the stars which are generally of the higher temperature of the freak class of star, blue or red? And are they rising or falling?

Dr. Harrison.—With regard to the red stars, I am not at all clear as to whether they are equally distributed among the heating or cooling class; my impression is that they are all cooling stars.

Mr. Meares.—This may be just a point of temperature.

The President.—Was there not something published some time ago about four or five red stars in one of the star clusters? I think they were described as hot stars.

Mr. Meares.—Do you mean the Wolfe Rojet stars?

The President.—Yes, I do. My recollection is that they were looked upon as hot and variable stars.

Dr. Harrison.—They might be very hot stars and yet they might be falling in temperature.

Mr. Meares.—Yes, I see your point.

The President.—There are some questions which I should like to ask. We have just had during the last few months a long series of papers and articles from Professor Bickerton. He told us that on grazing collision of two stars, a third body is formed, and it appears as a new star, and I think, if what he states is the case, there should be something to show us whether these stars are rising or falling. Is there anything ?

Dr. Harrison.—I do not think it has ever been observed.

The President.—The new star ought to be a rising-temperature star.

Dr. Harrison.—No, the new one would be a cooling star.

The President.—Yes, when on the wane, but before that a rising one. Is the planet Neptune a rising or a falling star ? Would that give us a spectrum ?

Dr. Harrison.—I do not think it gives a spectrum.

The President.—I am right, am I not, Mr. Meares, that the planet is considered to be still hot ?

Mr. Meares.—I think so. I believe it is rather a difficult proposition.

The President.—I am doubtful also whether there is a spectrum. If there is, it would be very interesting to find out.

Is there any evidence to show that the nebulous state is a cooling one ?

Dr. Harrison.—The nebula is condensing and therefore rising in temperature up to a certain point.

Mr. Meares.—Would not the extreme tenuity of the nebula be against it ?

Dr. Harrison.—No. The absence of evidence would not necessarily be against it.

The President.—As Mr. Meares says, the tenuity of the nebula might go against it.

Mr. Bose.—I notice that helium has been taken in this case, but do you mean to say that all stars contain helium.

Dr. Harrison.—I think so, all stars probably contain helium, but I do not think that its absence would matter.

The President.—Is the amount of helium in the star any proof of temperature ?

Dr. Harrison.—It would be difficult to get the amount, but the condition of the helium spectrum would be some indication perhaps.

Mr. Meares.—There is no doubt that they have all got it there, but the question is to trace it.

A very cordial vote of thanks was returned to Dr. Harrison for his interesting paper.

The Chair was now kindly taken by Mr. Simmons while the President read the next paper on the Old Delhi Observatory, which he amply explained by a sketch on the blackboard and pictures on the screen, which proved of the greatest interest.

Mr. Simmons.—Ladies and Gentlemen, the time has now come for you to put such questions to our President as may have been suggested by his paper this evening; a most interesting paper to us as bringing up the question as to whether Delhi would be a suitable place for an Observatory.

Dr. Harrison.—What degree of accuracy could they get with their instruments? Could they read to one degree?

Mr. Meares.—I think they got down to about $\frac{1}{4}$ of a degree. Mr. Maunder had a paper either on the Benares or Delhi Observatory, I forget now which. I believe that they got a mean accuracy of two lines of them to $\frac{1}{4}$ of a degree.

The President.—I think that is the way they did it. They depended on mean figures, as Mr. Meares says. They actually had 20 sets to select from.

Mr. Meares.—The Benares Observatory was very good, but in the case of the others I know very little.

The President.—As regards the question as to whether Delhi would be a good place for an Observatory or not, personally I should say it would not, on account of the dust.

Mr. Meares.—What about Calcutta?

The President.—Calcutta certainly has its dust and smoke, but the former is nothing in Calcutta compared to Delhi.

Mr. Meares.—Does not Calcutta suffer from vibration?

Dr. Harrison.—I have never had any dust or vibration troubles at the Observatory, but we have not very large instruments.

Mr. Simmons.—On what are those restorations based, are they based on any records that have come down to us?

The President.—I think they are based on what is left at Benares and Jeypore, as well as old Sanskrit writings.

Mr. Simmons.—It would be interesting to know whether this Observatory was built from the Hindu point of view or from the Arabic point of view.

The President.—I am afraid I cannot say fully, but it was Hindu built and contained modern ideas, if the provision for Greenwich longitude is any criterion.

Mr. Dutt.—Was Greenwich known to the Indian Astronomer in 1770—I mean is that the proper translation of the writings ?

The President.—I do not know, but I think the translations refer to Greenwich, Italy and Japan.

Dr. Harrison.—Has any one taken any observations by these instruments ?

The President.—Yes ; Babu Bhola Nath has tested them and sells an interesting book on them. He has tested some of them but not all ; some are still in course of restoration.

Mr. Simmons.—In returning a hearty vote of thanks to our President for his most interesting paper, which carries us back to the very earliest times when observations were made, I would remark that perhaps a visit to the Old Delhi Observatory would not only be an interesting but a very instructive undertaking to all interested in Astronomy.

The President next exhibited some very interesting photographs on the screen of nebula taken by Dr. Richie of America.

Mr. Meares.—Do you happen to know what exposure these were taken with ?

The President.—Three or four hours I believe.

In adjourning the Meeting the President remarked that the Astronomical Society of Barcelona intended holding an Exhibition next May and June and that this Society hoped to be in a position to forward a few exhibits. He invited help from Members. The Meeting was then adjourned to Tuesday, the 30th January 1912.

Inorganic Evolution.

BY DR. E. P. HARRISON.

Inorganic evolution deals with the changes which have gone on, and the causes that have been at work in building up from much simpler forms, the 70 or 80 so-called chemical elements as we now know them.

Some years ago a most remarkable theory which is nowadays generally accepted, and which has revolutionised modern thought in many directions, was put forward by Charles Darwin. It is known as the theory of organic evolution and it suggests that each species of plant and animal is not the result of special creation ; but has been modified by its surroundings and has become gradually changed by the action

of natural causes from a more simple to a more complex type. On this theory all plants and animals at present existing are descendants of a very few ancient and much more simple types of life. The extreme difficulty of Darwin's problem is obvious, if it is realized how very little is known of the meaning of the word Life, and with what exceedingly delicate, complex and variable material the organic evolutionist has to deal, when he attempts to trace the ancestry of a species of plant or animal.

The problem of Inorganic Evolution which I am going to state this afternoon is one which logically should precede the Darwinian problem. For in attempting to trace the ancestry of the substance iron, for example, we are attacking what is clearly a simpler problem than when we try to determine the form of living being which preceded and devolped into (say) the modern living cat or the human being. Dead cat would not be so hard to deal with, as it can be analysed, and the chemist could tell us with great nicety of what it is composed. In fact we should have eliminated the great unknown factor, Life, from the inquiry.

However, the question of the origin of living species was actually propounded and had been partially answered before the idea of the evolution of the chemical elements seriously arose.

In all old books on chemistry it is stated as an article of faith that matter exists, when it has been simplified as far as possible, in the form of about 70 *elements*. Examples of such elementary substances are iron, oxygen gas, carbon or tin. An element cannot by any means at the disposal of the chemist (so we are told) be split up in anything simpler.

Now within the last few years our faith in the integrity of the elements has been breaking down in several directions: First, recent work in physics has shown conclusively that simpler forms of matter than any of the elements actually do exist, and that in certain cases there is a high probability that some of the elements are slowly and spontaneously changing into others. The old Alchemist's dream is being realised. Secondly, great changes of temperature, whatever the old text-books may say, do seem to have the effect of breaking up the elements into more primitive forms. It is about this last effect that I am going to speak to-day.

Nearly all the evidence concerning this temperature effect on the elements is obtained from Astronomical observations, simply because we do not possess on the Earth any sources of heat which in any way approach some of the hotter stars.

Here on the Earth we have several different gradations of temperature with which to experiment on the elements :—

(i) There is the bunsen burner flame.

(ii) There is the blow pipe flame in which a current of air is blown through the gas, and raises the temperature of the flame considerably.

(iii) There is the electric arc flame, which is much hotter than the blow pipe flame.

(iv) There is the electric spark. It is the hottest source known on the Earth and can volatalise or make gaseous a great many of the elements, so that they become luminous.

The spark is produced by means of an instrument known as an induction coil, and the temperature of the spark depends to a large extent on the size of the coil.

So much for the various means which we have, on the Earth, for producing very high temperatures.

The question now arises, how are we going to detect whether any particular element, exposed to these high temperatures, is split up in to something simpler, or not ?

In order to explain this, it is necessary to digress a little and to describe an instrument known as the spectroscope.

The light which is emitted by any of the flames above mentioned, consists of a series of vibrations or waves, which travel outwards in all directions, and give us the sensation of light. If we put into the flame a small portion of an element which is easily vapourised by the high temperature of the flame, the flame becomes coloured, as can be seen with the eye. The colouring of the flame means that the glowing metallic vapour sends out a *special* kind of wave of its own of a perfectly definite length. If now we let some of this light fall on the spectroscope, the instrument is so constructed that light waves of one particular length always pass to a fixed position in the instrument so that bright narrow bands or lines of light are seen, which always occupy a fixed position in the instrument. This is because in the case of light from any element only definite types of wave are given out.

It is more usual for several different kinds of waves to be emitted by a glowing element. Barium, for example, gives us 8 or 10 well-marked bands, in fixed positions. Iron gives us some hundreds. Such a series of lines is called the spectrum of the element. It is very important to realise that the positions of these lines are always fixed relatively to one another ; thus if we have once seen and measured the positions

of the lines produced by any particular element we can always identify that element again.

The simplest method of identification is to photograph the spectrum; the positions of the lines can then be determined on the plate at leisure, and one spectrum can be compared with another spectrum. The spectra of different elements are entirely different from one another.

It is now possible to describe how the evidence for the actual splitting up of the elements has been obtained. Suppose we observe the spectrum of barium heated in the bunsen burner; it is perfectly definite and can be mapped or photographed. If we expose barium to the higher temperature of the electric arc, we get a similar spectrum, so far as *position* of the lines goes, but some of the lines will be found to be rather *brighter* than the corresponding lines in the flame spectrum. Such brightened lines are called *enhanced lines*.

If now barium is placed under the influence of the much higher temperature of the *spark*—the enhanced lines become fewer in number, and much more clearly marked, while some new lines may make their appearance.

A map, or photograph of the enhanced lines, is called the *Enhanced Spectrum.* Enhanced spectra have been obtained for a great many elements, even using such temperatures as are available on this earth—and by laying one enhanced spectrum on the top of another, we can get a combined enhanced spectrum for two elements or for three or for more. Such a combination of enhanced spectra has been called a *test spectrum* by Sir Norman Lockyer.

The production of enhanced lines in the spectrum of an element, as the temperature is raised from that of the flame to that of the spark, indicates that some change is going on in the molecules or atoms of the heated element, and we may well suppose that at higher temperatures than we can obtain here, nothing but enhanced lines would remain. Such is actually the case—for on making a photograph of the spectrum of the hottest part of the Sun, *viz.*, the Chromosphere—that spectrum is found to *coincide* almost line for line with the *test spectrum* obtained on the Earth in the way I have described.

The deduction is that in the Chromosphere of the Sun there exists all those elements which were used in compiling the test spectrum, at a temperature not less than that of the hottest electric spark yet produced.

Now there is every reason to believe that the Sun is by no means a very hot star compared with some.

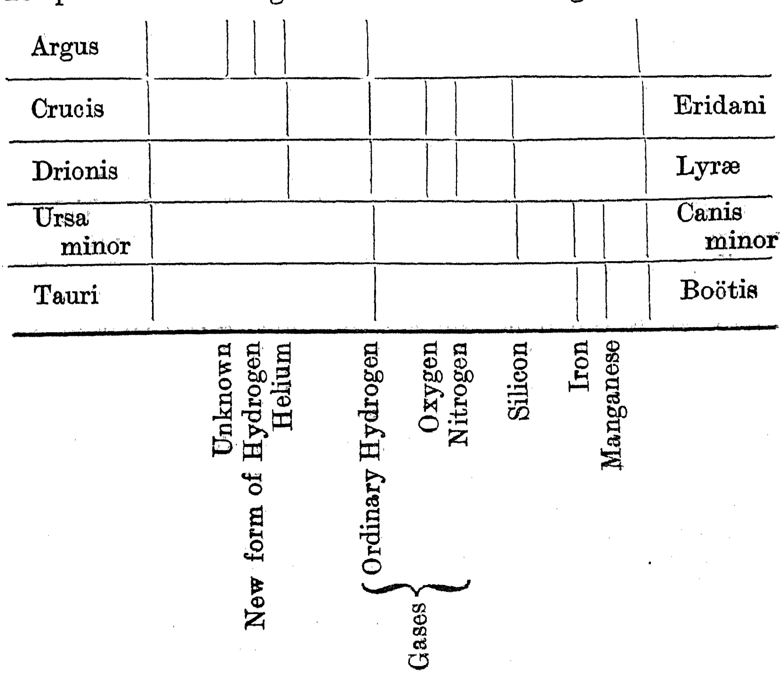
In most of the stars, it is found that there is a general decrease in the number of ordinary lines, and an increasing importance of enhanced lines, particularly the enhanced lines of iron and Hydrogen—and of the gas Helium, and also in some other stars which there is other reason to believe are the hottest, of all a certain number of the new, or *unknown*, lines which do not represent any known substance appear.

It is thus possible to classify the stars in some such way as this :—

Highest temperature stars	... Strong Helium lines and faint enhanced metallic lines.
Medium	... Faint Helium lines, Hydrogen lines and strong enhanced lines.
Lowest temperature	... Faint arc lines.

Some of these stars will be rising in temperature, others will be cooling, and so we are able to construct a map on the following plan :—

Temperature increasing. Cooling stars.



The general tendency is evidently to simplify all elements in the very hottest stars, into Helium and modified Hydrogen, and unknown lines, and those gases would therefore appear to be almost the simplest forms of matter existing, and to be the parents of the many elements that we see on the Earth.

As the stars cool, we apparently have aggregations going on among these gaseous atoms, producing finally the ordinary metals and other elements.

And now a word or two as to how we may regard the general march of events in the universe.

First we have the nebula stage. Further back than that it is hard to go. The nebulæ are probably Meteoric Swarms, gravitating together. The more the mutual attraction of the meteoric particles condenses the swarm, the higher rises the temperature, until the whole finally glows. The spectrum of such a well formed meteoric swarm consists of faint metallic lines and the ordinary Hydrogen and Helium spectra. Evidently this Helium and Hydrogen were driven out of the meteors by the heat, and so far no *changes* of the elements themselves have taken place.

As condensation increases, the temperature steadily rises, until we reach the stage in which the nebula has condensed and has become a *star*. Then goes on the gradual simplification of the *metallic* forms into those forms which give enhanced spectra, and finally when the star has reached its highest temperature all elements originally present in the swarm of meteorites have been reduced to Helium, and to some unknown forms which possibly possess still simpler atoms than Helium itself. Any Helium that was *originally* present in the meteors would remain as such and would, at the highest temperatures, be indistinguishable from the Heliums produced by dissociation of the other elements by heat. From the hottest to the coldest stars 10 groups have been found, each group at a different temperature and which contain 10 different genera of chemical forms varying from unknown forms through Helium, Hydrogen, enhanced Iron and Calcium, to ordinary forms of iron or other elements.

The irresistible conclusion is that the elementary forms are by no means constant, and that great changes of temperature break them up into much simpler atoms.

I must finish by alluding to another branch of work which has been converging on this subject, and which supports the ideas just explained, in a most remarkable way.

Certain new substances which have recently been discovered on the Earth, namely, Radium and Actmim, are

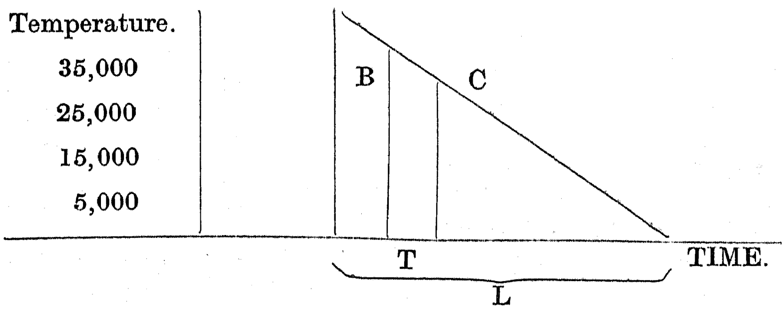
themselves known to be breaking up spontaneously into simpler forms, quite independently of any changes in temperature, and one of these simpler forms is undoubtedly Helium gas itself. Here then is additional evidence of the changeableness of the elements under proper conditions. We are led to speculate that the primeval form of matter may have been a gaseous substance like Helium, or possibly simpler, and that all other forms are derivatives of this simple atom, produced by association.

On this view we might regard radium as "reverting to type" or going back to its ancient primitive form.

Having arrived in the course of ages at a cool planet like the Earth, it is natural to enquire into the causes at work which determined the appearance of Life on the surface. The stages which you will have now be prepared to follow are somewhat like this.

Helium—Other gases—Metals and other elements as we know them—Complicated organic compounds always containing carbon (*e.g.*, Sugar, or protoplasm)—The same plus life.

Sir Norman Lockyer has constructed a very suggestive diagram to illustrate the comparatively short time, compared with the process of evolution among the elements, which has been occupied in the production of the living species we now see.



As time has proceeded from the 1st cooling of the hottest star groups, we find that the time T. occupied in cooling, say from 35,000° to 25,000°, is represented by the length of the line B. C.

But all organic evolution on this planet has almost certainly taken place within limits of temperature equal to not more than say 10° or 20° and the time occupied in the process,

has been variously estimated by geologists and biologists and something of the order of 1,000,000 years.

Now looking at the diagram, the time interval which corresponds to temperature interval of 10° or 20° is so small as to be imperceptible on the diagram—yet the total time for the hottest star groups to cool down to a temperature suitable for organic evolution to begin is represented on the *same* scale by the length L; thus the total time taken by the hot star groups in cooling down to 50° C. might well be 10, or 100, thousand million years, and even then we have only started measuring time from the instant the groups were *hottest*.

We have left out of account the incalculable ages which must have been occupied in building up from the nebulæ into the hot stars—and so as is usual when one begins to speculate in the broader paths of science, one reaches a hopeless inevitable barrier which the human mind cannot hope to penetrate.

Meteors.

By P. C. Bose.

The infinite dark space in which the Sun and the stars shine like so many brilliantly illuminated chandeliers, to human eyes seems ever to be wrapped in profound silence and mystery. Yet violent commotions are continually taking place. The interstellar and interplanatory spaces are filled with inconceivable myriads of meteors, too small and too distant to be visible by our telescopes. The new stars or novi, as they are called, and which are seen suddenly to appear from time to time, are nothing but the results of collisions against each other of these meteoric systems.

Wandering about aimlessly they happen to come within the sphere of attraction of the Sun, their paths are changed and thenceforward they go on revolving round and round the Sun—a member of its system.

Moving in long ellipses, their orbits sometimes cut the orbits of planets. It is clear that a time comes when these meteors occupy the same position as the planets do; then the meteors being smaller bodies—weighing from a few tons to a few grains—are attracted by the planets, they rush towards them and enter their atmosphere with tremendous velocities and are consumed by the friction thus induced. Then grand

meteoric displays occur. Such a display took place on our Earth last in 1866, and of which brilliant descriptions can be read in the books. We have never had an opportunity of viewing such a grand display. It is very probable that some of the meteoric systems have spent themselves. The Earth in its annual revolution round the Sun makes a good haul of thousands and thousands of them, but there may be thousands and thousands yet left.

While some are precipitated on the planets or are consumed, there are others which either escape and continue to move on in their orbits or are captivated by the planets and move round and round them. A good example of this is the ring system of the planet Saturn, and I believe that our own Moon has such an origin and that a good number of meteors may yet be moving about our planet.

Comets have been known to break up and appear to us as meteors. Biela's Comet is a typical example of this kind. It was a Comet of 6½ years period and was discovered in 1826. In 1845 at the fourth appearance of the Comet it was seen to be broken up in two, and in 1852 the time of the next return of the Comet it was lost, and since then no one has seen it. Now see what happened. In the year 1872 on the night of the 27th November there occurred a copious meteoric shower and the same phenomenon was repeated about the same date in 1885. Hence the conclusion may be drawn that the Comet had undergone further disintegrations and will not appear as a Comet again. What the immediate causes of such disintegrations are cannot be said with any amount of certainty, but collisions with meteors might be one of the reasons. As a matter of fact, Morehouse's Comet in 1908 when near the Sun came into violent collision with a body of meteors and narrowly escaped utter destruction. I could name some more Comets that have shown similar phenomena of disintegrations, but I think that the one I have just mentioned will be quite sufficient for our purpose. We may, therefore, infer that all meteoric displays are the outcome of the collisions of the Earth with a Comet or with the dense meteoric swarms.

And mighty are some of these meteoric streams—the length and breadth of some of these are sometimes enormous. In the case of the Leonids there are reasons to believe that the breadth is more than 100,000 miles and the Earth on the night between the 13th and 14th of November 1866 entered its stream at the head and moving at the rate of 18 miles a second took 5 hours to cross it. But its length far surpasses its breadth. The Earth encountered this stream for three successive years, and since then in its passage across the meteor's orbit

the Earth has encountered a few stragglers every year. These meteors have a period of $33\frac{1}{4}$ years. There are other meteoric showers which the Earth in its annual revolution round the Sun experiences. In fact, there is a shower every month of the year so to say. These showers have been named after the constellations in which their radiants are situated. They are the Bielids or the Andromedes, the Perseids, the Geminids, etc., etc. Up to the present about a hundred such radiants have been discovered.

Besides these visible meteors there are others called the telescopic meteors and which could be seen by telescopes of low powers and large fields of view. These meteors are very slow and generally their paths are confined within the same field of view.

The days of idle sentiment and imagining had long passed away. Science required a thorough, rigid, prosaic scrutiny into these things. From chemical examinations of the samples of meteors that fell on the surface of the Earth, it became possible to know their exact composition, and from a consideration of their chemical and physical aspects it was found convenient to divide them into groups, and accordingly they were named—the meteors, bolides or shooting stars, the fireballs and the meteorites. Of these classes the meteorites are comparatively rare. They are divided into Aerotites or Meteoric stones, Aerosiderites or Meteoric irons and Aerosiderolites, which include the intervening variations. These last are again subdivided into two groups, *viz.*, (α) the carbonaceous and (β) the non-carbonaceous. The pieces of meteorites that have been presented to our Society by His Highness the Maharaja Bahadur of Jalawar are of the latter (β) type. The fireballs are brilliant and slow and noiseless, although a few have been known to be of detonating nature. They are generally pear-shaped.

Generally a meteor appears at a distance of less than 90 miles and disappears at more than 40 miles. From a large number of computations Mr. Winning got the average values for beginning height and end height to be 76·4 miles and 50·8 miles respectively. For fireballs the height of disappearance is 30 miles.

If the paths followed by meteors, on a particular date, are carefully marked on a chart and produced backwards, a point is found in which they intersect each other. This point is called the radiant point. The radiants do not actually reside in the constellations they are named after, but only seem so on projection. In all meteoric observations the aim of the astronomer should be the determination of these radiant points.

This can be done by a very simple method, which has been too lucidly explained by Mr. Rakshit in the November number of the Journal of this Society to require any repetition here. Some meteors, such as the Perseids and the Lyrids, have been found to shift their radiants from fixed positions, and it is just possible that there are others that might be classed with them. Observations must be taken at different nights and the results kept separate for future comparisons. They will then show whether the radiants are shifting or not, and if shifting, the rate and direction of displacement. In fixing the radiants at least 5 paths must be taken.

There are other things equally important to an observer. The direction of motion, the duration of flight, the observed paths in R. A. and Dec., whether the showers are continuous or intermittent, etc., etc., are to be carefully noted. The last Geminid shower, which I observed on the night of the 15th of December last, was interesting in many ways. Some of the meteors were long and bright not lasting more than 2 seconds, and others short swift and pale blue lasting less than a second. There were some small ones of the appearance of red-hot pieces of iron. The meteors were observed most towards the east and south, a very few towards the west, but none towards the north. Another interesting feature about this shower was its intermittent nature—there was a distinct pause of some 10 or 12 mts. after every shower.

The study of this branch of Astronomy is very interesting. Though much has been explained, much yet remains to be elucidated. Naked eye observations are bound to be imperfect and erroneous, but that cannot be helped. Our refined instruments are perfectly powerless to cope with these erratic, fugitive little bodies. So the eye must be trained to take such observations as are most near the truth.

The Old Observatory of Jai Singh at Delhi.

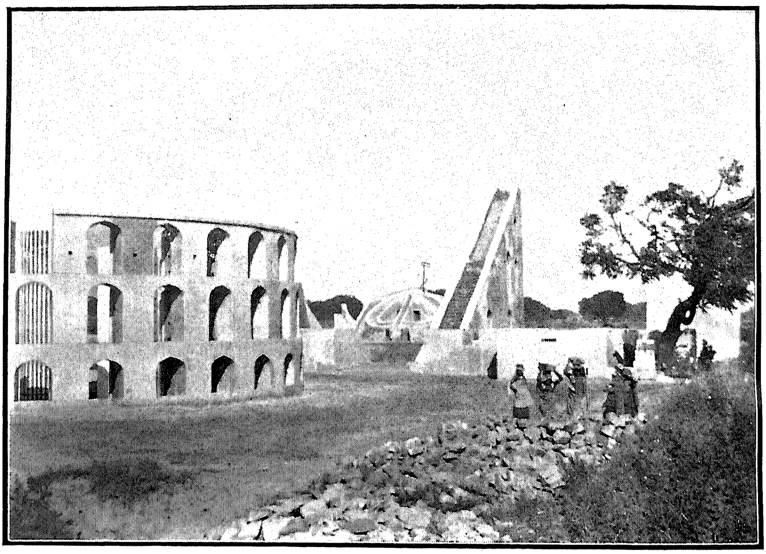
BY H. G. TOMKINS, C.I.E., F.R.A.S.

Visitors to Delhi will doubtless remember the quaint looking ruins which were until recently to be seen from the road leading from the Ajmere Gate of the City of Delhi to the Kutub Minar. They were the remains of an important observatory built by Maharaja Jai Singh in the year 1710 A.D. The

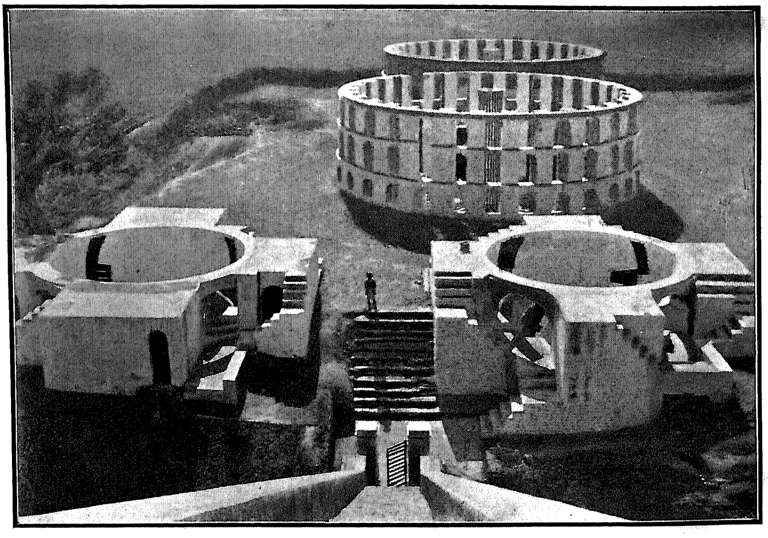
observatory was the first built of five, the other sites being at Jaipur, Benares, Ujjain and Mutthra. The one at Benares is of course still well known. The Maharaja seems to have been an early astronomer who grasped the fact that the instrumental equipment of his day was defective, and that the tables and calculations as then existing had in them large errors arising mainly from this cause. He, therefore, set himself to build an observatory in which observations of the positions of the heavenly bodies could be taken with an accuracy exceeding anything which had gone before, and as will be said further and in this paper, he kept this object in view in selecting the various contrivances which he built. Further he built the four other observatories in India named above by which the observations at Delhi could be checked. It is clear, therefore, that his aim was to take many observations and to get rid of instrumental and personal errors by using the mean figures, a process which as we are all aware is still in use.

Until lately it was not possible for a visitor to do more than admire the ancient ruins and to surmise what their general use must have been. Lately, however, the observatory has been thoroughly restored; the buildings have been repaired; the dials have been reconstructed and the degrees and other dimensions re-marked; so that it is now possible to take the observations of the heavenly bodies as of yore. Those who admire an ancient ruin will of course suffer some disappointment at seeing them disappear; but to those who delight in studying old scientific ways and thought, the place is full of interest and struck me on my recent visit to Delhi as being a subject which might appropriately be brought before our Society in India.

The instruments were all designed to determine either time or the positions of the Sun and other heavenly bodies, and the measurements all depend on a direct reading of a dial marked on the stone of the observatory itself. When the Sun was observed, the shadow cast either by a stone edge as in the case of the sun-dial or by a ring or the top of a rod or pillar were made use of. There is no evidence that I can see of anything in the nature of a telescope or microscope of any form having been adopted either for observing or the reading of any of the circles, nor is there any substitute for them in some form of sighting apparatus beyond probably a plain straight rod or a string placed or stretched in the direction of a heavenly body so as to indicate the place on the dial. The principle of the vernier so largely used on instruments of the present day does not appear. Consequently the readings must have been



General view of the Observatory.



The Ram Zantra and the Jayprakash Zantra.

Views of Jai Singh's Observatory at Delhi restored by the Government of India in 1910. Taken by Mrs. Tomkins, December 1911.

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1912

crude compared with those we now work with, and this I think would seem to be one reason for the number of instruments all devoted or capable of being applied to one or two classes of observation. The principles of these were time, altitude and azimuth, and right ascension and declination. The observations were made with more than one of the instruments, and thus a mean could be taken or one checked with the other.

There were four instruments in the observatory, the largest and most important of which was evidently the sun-dial known as the Samrath Zantra. The others were the Ram Zantra in two parts, the Jai Prakash Zantra in two parts, and the Misra Zantra in one part. The illustration given herewith shows a general view of the observatory. The gnomon of the sun-dial is in the centre of the picture, the Ram Zantra is the circular arched building to the right, the block to the left is the Jai Prakash Zantra, and in the distance on the right of the gnomon is the Misra Zantra.

The sun-dial consists of the huge gnomon seen in the photograph and the dial on which its shadow falls in order to indicate the time. This dial was a huge masonry construction below the surface of the ground. It has now been excavated and repaired so that the shadow of the gnomon falls accurately on it. I am sorry to say a large photograph whch I took of the dial has been destroyed by an accident. Its position, however, is round the foot of the gnomon and the arcs are described in the plane of the Equator. Thus as the angle of the gnomon is the latitude of the plane, the surface of the arc is normal to the edge which throws the shadow. The shadow before noon falls on the western arc and descends as the day goes on until at noon there is no shadow. Similarly after noon the shadow appears on the eastern arc or gradient and rises as the sun sets. The gradients are graduated so that the position of the shadow indicates at once the hour of the day. The gnomon is also graduated in order to determine the declination of the Sun north or south from the Equator. The method of observing this is well given in a little book on the subject by Lala Bholanath, Assistant Engineer of Jaipur, and I cannot do better than quote what he says :—" The graduations on the gnomon begin from the central points of the gradients on the edge of the gnomon and proceed upwards and downwards both ways. They are formed by engraving a scale of tangents for the different angles. The diversions counted upwards give the declination north of the Equator and those downwards give the declination south of the Equator. To measure the declination of the Sun, hold a rod with a sharp edge or point upright on the western edge of the gnomon before noon and on the eastern edge after noon and observe its shadow. Move

the rod up and down on the graduation of the gnomon until its shadow coincides with the edge of the gradient." The graduation on the gnomon will then indicate the declination.

Similarly the R. A. and Dec. of other heavenly bodies may be obtained by means of a thread along which the body has to be sighted and the positions of the thread on the graduations read.

This is the most important of the instruments in the observatory and the most imposing. The author of the little book I have mentioned states that another instrument connected with this sun-dial existed at its base by which the altitude and azimuth of the Sun could be determined, but this is still buried.

We come now to the Ram Zantra, which is hardly less imposing than the great sun-dial. It consists of a high circular wall with a tall pillar in the centre. The walls are arched to enable the observers to observe the sky through the apertures. The pillar is graduated in degrees by bands of red and white from the top to the bottom, and these are extended to the base of the walls by means of stone radii and the graduations are then extended up the walls all round. By fixing the zero graduation due north, therefore, it is possible by means of the shadow thrown by the central pillar or by a rod held as a sight to determine the azimuth of the Sun or a heavenly body. Similarly the stone radii and the walls are graduated to determine the altitude of the Sun or body above the horizon, the graduations being of course concentric circles with their centres at the centre of the pillar. The height of the pillar has been so arranged that when the altitude of a body is 45°, the shadow falls exactly at the junction of the stone radii with the base of the walls. It will thus be apparent that when the altitude of a body is less than 45°, the shadow or end of the sighting rod will be on a spot on the walls above the ground and the less the altitude, the higher it will be. To get over this, footholds have been made in the walls and up these the observers had to climb in order to make his observation. I can only imagine the observers to have been young and active, as I very much doubt whether it would have been possible to persuade some of our present day astronomers to make the ascent. I certainly should not care to observe stars with this instrument at an altitude of, say, 10 degrees. With this description before him, the reader will of course understand the reason for the openings in the walls of the instrument. They were of course to enable the observer to get roughly the position of the body. Similarly the stone radii were built

instead of a floor to enable an observer to get up to the pillar in the centre so as to make his observation. Otherwise there would of course have been no difficulty in making out the graduations on the floor. The consequence is that in certain positions of the heavenly bodies, the shadow or rod, as the case may be, falls on a space instead of on the graduation, and similarly with the openings in the walls. To provide for this a second structure has been made in which the apertures and spaces are supplementary to those in the other and we thus are able in one or other of the portions to observe the heavenly bodies in any position in the heavens except the zenith, when they are exactly over the centre of the central pillar.

The next instrument is the Jai Prakash Zantra. This is also in two parts for a similar reason to the Ram Zantra —namely, to enable the observer to approach the various graduations to read them. The instrument is a hollow hemisphere on which are marked out the various lines of right ascension and declinations, as well as circles to represent altitude and azimuth. It struck me that it would have been more clear had the astronomer who designed this instrument kept to one class of observation and left out the altitude and azimuth lines, as when viewed with the openings before referred to in the structure, the result of the two systems being in the one hemisphere is very confusing.

The hollow sphere is plastered over inside and is then marked out with the various graduations. The very first thing one is struck with is the accurate idea that the inventor had of the fact that the pole of the heavens was inclined to the horizon at an angle of 28° 39′ and the consequent tilt of the equatorial line. The centre of the sphere corresponding to the pole is clear and the equatorial line is carefully put in its correct position, the lines of R. A. and declination falling into their right places so as to make observations easy. On these lines the paths of various heavenly bodies have been marked, representing probably the signs of the Zodiac. The maximum declination of the Sun is shown by means of a line. For purposes of observing the altitude and azimuth of a body, the rim of the hemisphere has been graduated, and there are also a set of graduations vertically to determine the altitude. For these purposes either a pole was fixed in the centre in order to obtain a shadow or to point a rod by, or else there was a ring tightly suspended from the four cardinal points of the ring. The rings are there, but I notice poles are being put in. Lastly we come to the Misra Zantra—a wonderful combination

of four devices—namely, the Samrath Zantra, the Dakshinobhitti, the Niyat Chakra Zantra and the Kark Rashivala.

The first is a form of sun-dial for finding time and the Sun's declination. The instrument is, of course, inclined at the usual angle and set due north and south. The main part of the instrument forms the gnomons which is divided into three—namely, a central gnomon and two side gnomons. The shadow from this is thrown on the graduated gradients to the east and west in the usual way. This part, therefore, performs a similar office to the large sun-dial.

The Niyat Chakra Zantra is the portion consisting of four semi-circles and a central gnomon. The instrument is intended to determine the declination of the Sun at four different hours of the day, and also to ascertain the hour of noon at four different places in other parts of the world, of which Greenwich was one. The position of the Sun was observed by holding a stick in various holes from the different observations and observing the position of the shadow on the semi-circles. The instrument is so built that this shadow falls on the semi-circles only at the hours for which it is built.

The Dakshinobhitti is a form of meridian instrument. It consists of a graduated arc on a perpendicular wall built in the plane of the meridian, *i.e.*, due north and south. The centre of the arc is marked on a stone. I imagine that there must have been some kind of excavation here, as it is not otherwise easy for the observer to get his head into position in order to sight the rod to the star or other body being observed. It is obvious that by means of this simple arrangement it was possible to obtain the altitude of a star on its zenith distance as it transited the meridian and incidentally also of course its declination, as this was the latitude of the place *plus* the zenith distance when the star was on the meridian for N. declination and zenith distance *minus* the latitude for stars of S. declination. It is interesting to find this device in the observatory, as it is one of the standard methods adopted by all observatories, and its presence shows that the astronomers of India at that time fully appreciated the advantages which attach to making of observations of the positions of the heavenly bodies in the meridian.

The Kark Rashivala—consists of a semi-circle and the back wall of the instrument with a peg at its centre. This device was used for determining the longitude of the Sun when the sign of Cancer was on the meridian. This does not seem to have been very much used, but is interesting as giving a direct method of getting the position at the time for which it was built.

The above are the instruments of this very interesting observatory, and it will be clear from what I have said that the idea was evidently to aim at precision by taking observations of a similar class by different means and checking one with the other. The accuracy is now far surpassed by more modern methods. The pointing of a stick or thread or the reading of a shadow with a necessarily diffused edge could not of course be strictly accurate, and in many of the observatories the stick had to be held in particular directions—for example perpendicular. Possibly there may have been some aid to this, but any one who has ever tried it will be aware of the difficulties attending such a method from this cause alone. The place, however, is full of interest to the astronomer, and I would recommend any of our members who may be near Delhi to visit these most interesting remains.

Memoranda for Observers.

Standard Time of India is adopted in this Memoranda.

For the month of February 1912.

Sidereal time at 8 p.m.

					H.	M.	S.
February	*1st*	...	...	...	4	41	45
,,	*8th*	...	...	...	5	9	21
,,	*15th*	...	...	...	5	36	57
,,	*22nd*	...	...	...	6	4	33
,,	*29th*	...	...	...	6	32	9

From this table the constellations visible during the evenings of February can be ascertained by a reference to their position as given in a Star Chart.

Phases of the Moon.

					H.	M.	
February	*3rd*	Full Moon	...	...	5	28	A.M.
,,	*10th*	Last Quarter	...	...	6	21	,,
,,	*18th*	New Moon	...	...	11	14	,,
,,	*26th*	First Quarter	...	...	0	57	,,

Meteors.

The following showers occur in February. They are not very brilliant showers :—

	R. A.	Dec.	Character.
February 5th—10th ...	75°	+41°	Slow, bright.
,, *15th* ...	236°	+11°	Swift, streaks.
,, ,, ...	261°	+4°	,, ,,
,, *20th* ...	181°	+34°	Swift, bright.
,, ,, ...	263°	+36°	Swift, streaks.

Planets.

Venus—Is a morning star. On February 15th at 8 P.M. its position will be R. A. 19 hrs. 26 mts. 59 secs., Dec. 21° 20′ 20″ S. Time of its rising will be 4 hrs. 3 mts. A.M. on the 16th February.

Saturn.—The position of the planet on 15th February at 8 P.M. will be R. A. 2 hrs. 49 mts. 32 secs., Dec. 14° 1′ 15″ N. The time of its setting will be 11 hrs. 12 mts. P.M. on the 15th February.

Mars.—The position of the planet on 15th February at 8 P.M. will be R. A. 4 hrs. 13 mts. 44 secs., Dec. 23° 25′ 48″ N. The time of its setting will be 0 hr. 55 mts. A.M. on the 16th February.

Jupiter.—The position of the planet on 15th February at 8 P.M. will be R. A. 16 hrs. 43 mts. 39 secs., Dec. 21° 31′ 10″ S. The time of its rising will be 1 hr. 13 mts. A.M. on 16th February.

Extracts from Publications.

The Nebular Hypothesis assumes that long, long ago, perhaps hundreds of millions or thousands of billions of years ago, all suns were either simultaneously or successively in a nebulous state ; that the nebulous matter of which they were originally formed was widely and quite uniformly scattered throughout space, but later began to gravitate toward certain slightly denser centres. The particles or masses moving toward these centres not doing so with equal velocities and momentum, or in the same direction, a slight rotation on an axis would result in the nebulous mass ; and, if by radiation of heat, the partially con-

tracted nebula or primitive sun still further contracted, his rotary velocity would have to continue to increase by reason of a mechanical law which we shall hereafter elucidate; and as soon as the rotation had increased so much that the centrifugal force of the outer equatorial border overcame that of gravity, a ring or belt would be shed or left behind from the equatorial region of this rapidly rotating nebulous sun.

This revolving ring, in obedience to well-known mechanical laws, must form itself into a spherical planet, rotating on its axis with ever-increasing rotary velocity; so that eventually a ring would also be shed from this large, newly-born, highly-heated, gaseous planet from which, in like manner, a moon or satellite was formed. As the contraction and consequent increasing rotary velocity of the sun and planets thus continued, ring after ring was, at long intervals, shed from which all the planets and moons of our solar system slowly evolved themselves to their present form and function, and this same evolution is still as ever going on. The solar system is slightly different to-day than it was yesterday, and will be different to-morrow than it is to-day.

Briefly stated, these are the fundamental doctrines advanced by the Nebular Hypothesis in respect to the gradual evolution of our solar system; and it is highly probable that every fixed star is an enormous central sun rotating on its axis and evolving by the same mechanical laws a solar system similar to our own.

In the two last topics in this series of articles, the writer will enumerate some of the strongest proofs in favour of the Nebular Hypothesis, and will also answer the principal objections that have so far been urged against it. I will here say merely that I am in full accord with the late Professor S. Newcomb's announcement "that the Nebular Hypothesis is indicated by the general tendency of the law of nature, and that it has not been proved inconsistent with any fact."

[*Popular Astronomy, Vol. XIX, No. 10.*

Eucke's Comet.—The following circumstances related by Dr. Backlund, in a recent number of the Ast. Nach. (4539), are mentioned here for reasons which will be obvious. There were two points about the appearance of Eucke's Comet last summer, which were remarkable: First, the object was brighter than it was expected to be; and, secondly, the observed places differed from the computed ephemeris by comparatively large quantities. When a sufficient number of these residuals had accumulated from observations made at Algiers, Johannesburg, and the Cape, Mr. Crommelin, with

his usual acumen, inferred that they would not have existed if a different value of the eccentricity had been used in computing the ephemeris, and wrote to Dr. Backlund suggesting an error of 10′ in this element. Dr. Backlund, on examining his work, found that there was a misprint in a certain publication of the elements, and that he had used an incorrect value of the eccentricity. The ephemeris being corrected in this sense, the residuals are no larger than would be expected, and Dr. Backlund says that the observations support his previously expressed views as to the mass of Mercury, and that the acceleration of the mean motion suffered a diminution in 1904.

[*The Observatory*.

Revd. A. L. Cortie (being called upon to give an account of his mission to observe the solar eclipse). The Vavan group of the Tonga Islands consists of one larger island, Vavan, some 9½ miles long in the east and west direction and 6¾ miles broad from north to south, and numerous smaller islands extending in the north-north-east and opposite direction over some 18 miles, with an extreme breadth of 19 miles. Vavan, the principal island of the group, is situated in latitude 18° 37′ S. and longitude 174° E., and was the station selected by the Joint Permanent Eclipse Committee for the Government Eclipse Expedition to view the total solar eclipse of April 28 last. The Admiralty detailed H. M. S. *Encounter* to assist in the eclipse operations, and every possible help was rendered to the expedition by Captain Colomb, his officers and crew. Accompanied by my assistant, Mr. McKeon, I left Stonyhurst on January 30, and sailed from Tilbury by the R. M. S. *Otway* on February 3, arriving at Sydney on March 16; Dr. Lockyer and Mr. McClean sailed in the steamer. The two Government expeditions left Sydney on the *Encounter* on March 25, and arrived at Vavan on Sunday, April 2. Although it is preferable that different parties of observers should separate as far apart as possible, in the present instance, the force of circumstances compelled the two parties to coalesce and to erect their instruments on the same site. The site chosen was the Admiralty coaling ground at the extreme south end of the Vavan harbour, latitude 18° 41′ S. and longitude 173° 59′ E. The harbour runs approximately north and south, and M. Stefanik occupied a position about one mile removed from our site in a northerly direction, at the Catholic Mission Reserve, the Australian Government party, under Mr. Baracchi, a position some half-mile yet further north on the recreation-ground of the chief village Neiafu, and Mr. Worthington's party a position some quarter of a mile still further north. On the day of the eclipse the weather condi-

tions, which were bad at our station, became better and better at these places in the order named, while the S. S. *Boverie* lying in the harbour not two miles away, had an almost perfect view of the eclipse. A clearing of the dense brushwood on the selected site, and of half a dozen cocoanut trees, was effected and the instruments were landed during the first few days after our arrival. Luckily the weather remained fine until the evening of April 10, and by that date the concrete foundations, made of cement, old coral, and dry sand had been built, the cœlostats erected in position, and the instruments placed under shelter. We were greatly indebted to Mr. Brooks, of Dr. Lockyer's party, for marking out the meridians and azimuths of the instruments. My instrumental equipment consisted of a 20-foot coronagraph, with a lens of 4-inch aperture, kindly lent by the Royal Irish Academy, and with the tube made of zinc sections, carrying an 8 × 10 camera at the end. This was set up horizontally in the azimuth of sunset. This instrument was under the charge of Mr. W. McKeon; side by side with it was set up the "Abney" 4-inch lens, fitted with a new camera-tube 33 inches long, the camera carrying quarter-plates. This instrument was under the charge of Lieutenant Elmsley.

The direct photography of the corona on a large scale for detail, and a smaller scale for extension, was thus provided for. A 16-inch cœlostat solidly mounted on a heavy box filled with stones, and this again on a concrete base, supplied light to these two cameras. Our spectroscopic outfit consisted of a prismatic camera and a quartz spectroscope. The former instrument was in the charge of Father E. Pigot, S.J., Director of the Riverview College Observatory, Sydney, who had joined me there. He was ably assisted by Engineer Lieutenant McEwan.

The prismatic camera was built up of a Grubb prism, refracting angle 40°, and transmitting a 7-inch beam of light, placed in front of a Dallmeyer 6-inch portrait lens of 30 inches focal length. This spectroscope, together with a one prism (60°) visual spectroscope for eye-observations of the times of the "flash," and a camera fitted with a Thorp replica grating, was rigidly fixed to the top of a table, the legs of which were embedded in the ground. In order to obtain the spectral arcs concentric with the disappearing and reappearing chromospheric crescent, the top of the table was lifted through 55° by means of two stout iron rods with screw adjustment. The deviation at He was thus reduced to 16° 28′. Wratten and Wainwright's panchromatic plates were taken out with us, and the spectrum was focussed for the red to green region.

It is in good focus as far as the K line. Father Pigot manipulated the instrument with great skill, and on the day of the eclipse, in spite of the cloudiness of the sky, a photograph taken of the upper chromosphere at the second "flash" shows the hydrogen series from Hd to Hi, as also some other lines. Though not adding much to our former scientific knowledge, I believe that this is the first time the red end of the spectrum has been photographed during a total solar eclipse. A 12-inch cœlostat supplied these instruments with light. The quartz spectroscope, which originally belonged to Major Hills, was kindly lent me by Prof. Newall, of Cambridge. This instrument was under my own particular charge, and I was ably assisted by the warrant officer Mr. Bright, torpedo-gunner. The 12-inch siderostat supplied it with light.

The fine weather broke on the evening of April 10, and from that date until the eclipse, we experienced very heavy torrentail rains and much cloud. The evening of April 28, for we kept Sydney time, and the morning of the 29th, were very overcast. The weather was clear during the partial phase, but near second contact the drop in temperature caused the formation in the humid atmosphere of dense cirro-cumulus clouds which were quite local. We lost fully two minutes of the 217 seconds of totality entirely, and during the remainder of the time the eclipsed Sun was obscured by a thick curtain of filmy clouds. To the naked eye, the corona was quite typically of the minimum character, with long equatorial extensions and open polar regions. The polar rays were just glimpsed. On the east the equatorial streamer was traced as far as one lunar diameter. In spite of the clouds a fairly good photograph of the corona was obtained with the Abney lens with 15 seconds exposure towards the end of totality. The negative shows some of the polar rays besides the equatorial streamers. With the long-focus coronagraph, with 20 seconds exposure, only the prominences and the fringe of the lower corona are visible. To the naked eye there seems to be a ring of brightness all round the Moon. Very little, if anything, was got with the quartz spectroscope, although I have not yet had time to examine the plates very carefully. The corona was not seen on the slit of the spectroscope until 20 seconds before the end of totality.

The Australian party is to be congratulated on having had much better, though not perfect, weather-conditions, and that they made good use of their opportunities is evidenced by the fine series of transparencies entrusted to my care by Mr. Baracchi, and now on exhibition in the library. I will put a few slides of the Australian results through the lantern, also a drawing by Captain Holfort, of the S. S. *Tofua*,

made under Mr. Baracchi's direction at the island of the same name, and an enlargement of a picture taken with an ordinary camera by one of my party of assistant sailors, seaman Smith. An examination of all the available material leads to the conclusion that the corona of April 1911 was markedly of the minimum type, and that, beyond the polar rays, there was no marked structural detail in the lower corona.

Mr. Baracchi used a Dallmeyer photopeliograph of 4-inch aperture in combination with an enlarging lens giving an equivalent focal length of 40 feet. The instrument was mounted equatorially. Mr. Merfield had charge of a pair of twin photographic lenses, also equatorially mounted, one a Dallmeyer Rapid Rectilinear of 4-inch aperture and 34-inch focal length, and the other a 4-inch Ross stopped down to $1\frac{1}{10}$ inch with focal length 21 inches. Mr. Dodwell used a combination of a pair of 12-inch parabolic mirrors fed with light by a 16-inch cœlostat, and Mr. Beattie a coronagraph consisting of an $8\frac{1}{2}$-inch calver mirror fed by a 12-inch cœlostat, which gave very bright images of about $\frac{3}{4}$ inch diameter.

Father Cortie illustrated his discourse by pictures, thrown on the screen, of the camp, of his instruments and of the corona taken during the eclipse. Dr. Lockyer followed with other pictures of the island and of the instruments used by the expedition of which he had charge, and of results obtained with them. Some photographs of the corona taken by Mr. Worthington were then thrown on the screen, and about these Prof. Turner said a few words. Mr. Frank McClean said a few words as to his share of the work in Dr. Lockyer's expedition.

[*The Observatory*.

The Latest Photograph of the Planet Mars.—(By Mary Proctor) Dr. Percival Lowell, of the Lowell Observatory, at Flagstaff, Ariz, has been finally successful in obtaining photographs of Mars, which establish beyond a doubt the reality of the canals of Mars. Heretofore, the value of the photos obtained by him in 1907 was questioned, on account of their minuteness being compared in size to the head of an ordinary pin. Doubts were expressed as to the amount of detail which could be seen on so small a scale, and magnification, it was said, only increased the difficulty by enlarging the silver particles upon the plate, wherever its sensitive surface had been exposed to the light.

With regard to photographs of Mars obtained October 11, 1911, with the Lowell refractor, 24-inch aperture, the images

made at one-minute intervals of exposure, each of three seconds, Dr. Lowell writes as follows, in a letter dated November 9, 1911 :—

"The following, therefore, will interest you and the public generally. The magnification used for the photographs is now 178 diameters. This, on a disc of twenty-four seconds of arc which Mars presented at the last opposition, gives for the photographic images a diameter 2·3 times that of the Moon to the naked eye, and a superficies of over five times that presented by our satellite to naked eye vision—rather a surprising revelation this as to the size of our photographs.

Believe me, yours very truly,

(Sd.) PERCIVAL LOWELL."

The diameter of Mars at the last opposition was 24 seconds of arc less than now. Superficies, in the above letter, means surface of original photographic images, which then covered an area over five times that presented by the full Moon to the naked eye, the telescope magnifying one hundred and seventy-eight diameters. While the canals are plainly visible on the photographic plate, they will not bear printing processes. On examining the enlarged image through a screen by a stereopticon an immense amount of elaborate detail appeared, several of the canals being plainly in evidence. As these photographs were taken a month or so before Mars had reached its nearest to our planet, we may look forward with interest to those which will be obtained on the date of nearest approach.

[*English Mechanic.*

Schaumasse's Comet will pass its nearest point to the Sun on February 5 at 8 P.M. It is now approaching both Earth and Sun, and it brightness is therefore increasing, and will continue to do so till nearly the end of January, when it will be at least as bright as the tenth magnitude, and, therefore, discernible with moderate telescopes. There is no prospect of its becoming visible to the naked eye.

It will remain a morning star throughout its period of visibility. Its positions on the days named will be—

	R. A.			Dec.
	H.	M.	S.	
Dec. 16	14	11	16	2° 8′ N.
,, 20	14	27	16	1° 9′ N.
,, 24	14	43	42	10′ N.
,, 28	15	0	34	49′ S.
Jan. 1	15	17	52	1° 47′ S.

The motion of the Comet in the sky is nearly parallel to that of Venus which is now a bright morning star. The Comet is about 4° west of Venus and 14° north of it, these figures remaining nearly constant throughout the month.

[*English Mechanic.*

Several of the papers read at the Astronomical Society's December meeting were on techincal points connected with the measurement of star photographs, but an address by Mr. Hope-Jones, who exhibited and described a Synchronome Astronomical Regulator, was distinctly practical. This is an electric clock, not new as to its elementary principle, for it consists of a pendulum kept swinging by the fall of a small weight which is raised after its fall by the armature of an electro-magnet; but the novelty and improvement lie mainly in the way that the falling weight gives the impulse. On the tail of the pendulum, below the bob, there is mounted a small, delicately poised wheel, with its plane in the plane of swing of the pendulum and the impulse-weight, or rather a round steel rod projecting from it, falls on this wheel every second, immediately after the pendulum has passed the middle point of its swing in either direction. The weight pressing on the periphery of the wheel sets it rotating and exerts a small force in direction of the swing until the pendulum has swung clear of the weight. The latter then continues its fall on to a contact piece, and thus completes a circuit which passes through an electro-magnet whose armature replaces the impulse-weight in its original position, and through the electro magnet which actuates the dial-work, and also, Mr. Hope-Jones says, through any number of subsidiary dials and chronographs. It should be added that the weight, when replaced by the armature, is held up by a catch, which the pendulum releases by a touch at its return swing, and the process is repeated, so that the contact is made, and the signal sent every second.

[*English Mechanic.*

At the B. A. A. meeting in November, Mr. G. F. Chambers occupied sometime in giving a very nicely illustrated discourse on the rather remarkable solar eclipse that is going to happen next April. He treated the matter rather from the point of view of Baldeker, instructing his hearers how they could reach the line of central eclipse in the easiest and cheapest way, but some remarks that followed were in a more astronomical vein. To set down in what way this phenomenon is of especial interest, I must ask to be allowed to refer to elementary principles of eclipses; but first I would say, referring to a diagram and explanation in my letter of October 20 last, that the line

of central eclipse runs very obliquely from south to north (it begins its course in Venezuela and ends in Russian Asia), because it happens in the spring, when the Earth's axis as seen by a hypothetical observer on the Sun, inclines to his right, and, secondly, because the Moon is at its ascending node. But, leaving this and turning to another point, if we look at the diagram about eclipses in any text-book, we shall see that if the Moon is near the Earth—that is, at perigee or nearly so—when she eclipses the Sun, the eclipse will be total, and if the eclipse happens quite at perigee the Moon's shadow on the Earth will be large. On the other hand, if the Moon be comparatively far from the Earth, the eclipse will be annular. Next April the Moon will be in apogee on April 9 and in perigee on April 22, and the eclipse will happen on April 16, about midway between these dates, which seems to define approximately between totality and annularity. (The distance of Sun from Earth, of course, makes a difference; but in this case the Earth happens to be very nearly at mean distance from Sun.) Further, the Moon is always nearer to the observer when on the meridian than when on the horizon, assuming—which is very nearly the case—that her distance from the centre of the Earth remains the same. This will be understood when it is remembered that when the Moon is on the meridian her actual distance from the observer will be her distance from Earth's centre diminished by the radius of the Earth; but when on the horizon, or in any other position, her distance from the observer is her distance from the Earth's centre diminished by less than the Earth's radius. A small diagram of a triangle right angled when the Moon is on the horizon will make this clear. This well known circumstance gives rise to a correction called "augmentation of Moon's diameter." This being so, on April 16 next, when the Moon rises in Venezuela, her distance from Venezuela being large comparatively, the people there see an annular eclipse of the Sun; but as the eclipse track crosses the Atlantic, the altitude of Sun and Moon increases; the Moon get nearer to the observer for the reason above mentioned, and the eclipse becomes total. After this total phase, as central eclipse passes eastward, the eclipsed Sun will be lower down, and the phenomenon will be again only annular. This is, in the main, the reason of this somewhat unusual phenomenon, though it is complicated by other circumstances which need not be considered now. Naturally, the prediction of the places where the eclipse will be total depends on the value of the Moon's diameter adopted in the computation, and the N. A. predicts totality only in Spain, and that for not a second, whilst the French ephemeris says it will be total for six seconds in Spain

and for two seconds near Paris ; but as the duration of recent eclipses has generally been shorter than predicted, it is probable that the British N. A. will be found to be more correct, and, in fact, there may be no totality at all.

[*English Mechanci.*

Notices of the Society.

Election of Members.

The attention of members is invited to Bye-Law No. 14, regulating the election of persons who desire to join the Society. It is hoped that those who are already members will induce others to join. Forms of application can be had from the Secretary, Mr. P. N. Mukherji.

The Library.

A subscription list exists and several members in Calcutta have subscribed and enabled the Council to make a beginning with the Library. Other members outside Calcutta, however, have not, except in one or two cases, yet come forward, and as the Library will be one of the most important adjuncts of the Society, and will be available to members both in and out of Calcutta, those who have not yet done so are invited to help the Society in making progress with this important branch of the work. Suggestions as to useful books for the Library will also be welcomed by the Librarian.

A number of books have already been received and can be borrowed by members in accordance with the Bye-Laws.

The books available can be ascertained from the Assistant Librarian and a catalogue will be issued shortly. The reading room of the Society in the Imperial Secretariat is now opened for the use of members daily from 5 to 7 P.M. except on Wednesdays and holidays and from 3 to 5 P.M. on Saturdays unless that day is a holiday.

Subscriptions.

Subscriptions for the current session fell due on 1st October 1911. Those who have not paid in their subscriptions are requested to remit them to the Treasurer at their convenience.

Papers for Meetings.

It is requested that drawings which accompany papers for reproduction in the JOURNAL may be made with Indian ink on white paper. This will insure a clear reproduction.

Meetings for the Session 1911-12.

Ordinary Meetings.

1912.	1912.
February 27th.	May 28th.
March 26th.	June 25th.
April 30th.	

The Meetings will commence at 5 P.M. and, until further notice, will be held in the Imperial Secretariat (Treasury) Buildings.

Addresses of Officers.

Owing to inconvenience which has arisen from addressing the Officers of the Society at their private address, it has been decided to receive communications on the business of the Society in future as follows :—

	To
Money Orders or letters containing money or cheques.	U. L. Banerjee, Esq., Office of the Accountant-General, Bengal, 3, Koila Ghat Street, Calcutta.
All other communications	*(Name)* ....Esq. *(Designation)* ....of the Astronomical Society of India, Imperial Secretariat (Treasury) Buildings, Calcutta.

It is requested that communications may be addressed accordingly.

Officers and Council.

FOR THE SESSION 1911-12.

(1) *President* . . . H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.

(2) *Vice-Presidents* . . (1) COL. S. G. BURRARD, R.E., C.S.I., F.R.S.

(2) J. EVERSHED, ESQ., F.R.A.S.

(3) SREE RAJA A. V. JUGGA RAO BAHADUR GARU, F.R.A.S., F.A.I., F.R.M.S., F.A.S. & C.

(4) H. H. THE MAHARAJA RANA BAHADUR SIR BHAWANI SINGH, K.C.S.I., F.R.A.S.

(3) *Secretary* (*Scientific*) . DR. E. P. HARRISON, PH.D.

Do. (*Business*) . P. N. MUKHERJI, ESQ., M.A., F.R.E.S., F.S.S.

Treasurer . . . U. L. BANERJEE, ESQ., M.A.

Directors of Sections—

Lunar Section . . H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.

Meteor Section . . B. N. RAKSHIT, ESQ., B.A.

Variable Star Section . LIEUT.-COL. LENOX-CONYNGHAM, R.E., F.R.A.S.

Instrumental Director . S. WOODHOUSE, ESQ.

Librarian . . C. T. LETTON, ESQ.

Editor . . J. J. MEIKLE, ESQ.

OTHER MEMBERS OF THE COUNCIL.

P. C. BOSE, ESQ.

MRS. PERCY BROWN.

J. C. DUTT, ESQ., M.A., B.L.

H. B. HOLMES, ESQ.

F. W. HAUSE, ESQ.

A. T. MITRA, ESQ., M.A.

J. C. MITRA, ESQ., M.A., B.L.

SARODA CHARAN MITTER, ESQ., M.A., B.L.

W. J. SIMMONS, ESQ.

C. K. SIRCAR, ESQ., C.E., M.S.A., M.S.E.

The Journal of the

Astronomical Society of India.

VOL. II.] SESSION 1911-1912. [NO. 4.

Proceedings of the Meeting of the Society held on Tuesday, the 30th January 1912.

H. G. TOMKINS, C.I.E., F.R.A.S., *President*, in the Chair.

P. N. MUKHERJEE, M.A., F.S.S., }
E. P. HARRISON, PH.D. } *Secretaries.*

The ordinary monthly meeting of the Astronomical Society of India was held in the Imperial Secretariat Buildings on Tuesday, the 30th January 1912, at 5 P.M.

The meeting was opened by the President, who asked Dr. Harrison in the temporary absence of Mr. Mukherjee to read the minutes of the previous meeting, which were then confirmed.

The following presents were then announced as having been received since the last meeting, and the thanks of the Society were accorded to the respective donors :—

1. Journal of the Royal Astronomical Society, Vol. LXII, No. 1.
2. Journal of the British Astronomical Association, Vol. XXII, No. 2.

3. Bulletin of the Astronomical Society of Barcelona for November 1911.
4. Revister Di Astronomica for December 1911 Annov No. 12.
5. Results of the Meteorological Observations made at the Radcliffe Observatory from 1900-1905, Vol. XLIX.
6. Index to Vol. I of the Journal of the Astronomical Society of India, by Mr. Lawrie.

The President next read the following list of members who had been elected by the Council since the previous meeting of the Society. The elections were duly confirmed :—

1. Mr. H. M. LANSDALE.
2. ,, T. A. FERRIER.
3. ,, J. C. BELL.
4. ,, P. F. LINTON.
5. Mrs. LINTON.
6. Rai Bahadur Pandit PARMANAND CHATURVEDI.

This was followed by the admission of new members, who signed the roll, and the President then announced with reference to the programme of work decided on for the session that the first of the three public lectures had been fixed for Friday, the 9th February 1912, at 5 P.M. Col. S. G. Burrard, R.E., C.S.I., F.R.S., a Vice-President of the Society, had consented to give the first lecture, his subject being "The Earth as a Planet." The Hon'ble Sir James Meston, K.C.S.I., would occupy the Chair and the Municipal Corporation had kindly allowed the Society the use of the Town Hall for the purpose. The lectures were free and open to any one who cared to attend, whether they were members of the Society or not. The President hoped that all members would take advantage of the opportunity offered to hear a lecture of the kind arranged for and would bring their friends, and also induce as many as possible to come.

The President then asked Dr. Mullick to give his paper on the Motion of the Planets. In doing so he pointed out that the paper was one of a class which members had not hitherto had before them—its nature being mathematical This word was rather apt to terrify some who were not experts in the subject, but it was necessary to represent all classes of astronomical works in the Society, and he had no doubt that if members gave Dr. Mullick their careful attention, he would be able to make the subject interesting to all of them.

Dr. Mullick then gave a most interesting paper, illustrating his remarks on the blackboard.

The President.—Dr. Mullick has, I think, justified the remarks I made before he began, that he would be able to make the subject in hand interesting to members. I do not think I have ever seen the matter handled more clearly and made more interesting, and I am sure from the attention which it was evident to me was being given during the time that Dr. Mullick was speaking that other members felt the same thing. Two things struck me: One was that it would be a very useful and instructive exercise for members to take their star charts and to map out on them the paths of some of the planets from night to night. It would require very little time or trouble, and also very little technical knowledge. Mars and Saturn were now available for the purpose, and if members will try this, they will get in a practical manner a graphical representation of the curious apparent paths of the planets which Dr. Mullick had been discussing. They will learn more in this way than by any amount of book reading and theorising, and they will then be able to realise the practical meaning of that part of the subject. The other point is the excellent illustration which Dr. Mullick has given them of a single simple cause often accounting for quite a large number of complicated observations. It often happens that we begin at the wrong end of the string, and consequently we pick up a lot of loose ends which when considered together are most puzzling and complicated. Some general and simple key is then to be applied and the puzzle is cleared up. This happens so often in natural research that in undertaking a discussion of data at hand it always seems to me to be advisable in the first place to look for some simple and general explanation, and as a rule to reject complications, or at any rate to doubt them.

The hearty thanks of the meeting were then accorded to Dr. Mullick for his interesting paper.

M·. W. Hanley then read a note on a base for a large telescope which was being put up at Barrackpore and explained the details of the structure by means of a plan.

Mr. Sarkar.—Would it not make the base more stable if the pillars were battened ?

Mr. Hanley.—I thought of it, but in view of the size of the base on which they stand, it did not seem necessary. The height of the pillars is not great in comparison to their size and distance apart and the whole is amply strong. Moreover as the base is south of the house, it is protected from the Nor'-westers and there will not be much wind pressure.

Mr. Sarkar.—In order to prevent vibration, would it not be advisable to separate the part of the upper concrete on which the siderostat is to rest from the part on which the tube is to be ?

Mr. Hanley.—It would certainly be a safeguard, but I am doubtful whether tremors will occur.

Dr. Harrison.—It seems to me that vibration is more likely to occur from beneath the whole structure. In Calcutta this is certainly the case, and if, as I gather, the vibration increases in effect with the size of the instrument, this may be rather a costly experiment.

The President.—I don't think there is anything like the vibration in Barrackpore that exists in Calcutta. In Calcutta I should say it would be impossible to do much.

Mr. Hanley.—The soil on which the base at Barrackpore is built also seems to me to be pretty good. However, of course, no precaution against vibration should be neglected.

The thanks of the meeting were then accorded to Mr. Hanley for his interesting note.

Mrs. Tomkins then handed in some slides of the old observatory at Delhi which she had developed since the previous meeting. They were interesting as showing the solar shadow on the large sun-dial. One of the other instruments was also well shown.

The President then showed some slides of star clusters and nebulæ taken by Dr. Ritchey of America, which were greatly admired.

He then stated that there was a piece of original work on the Moon which could be done by any one with a little spare time and which required nothing but a small amount of perseverance. He referred to the craterlets on the Moon's surface. In studying the origin of the lunar formations the distribution of these craterlets was a very important matter. There were hundreds of them, and though there had been many vague statements regarding them, as far as he was aware no systematic attempt had ever been made to tabulate their distribution. The work could be done from photographs which he could supply and would be eminently suited to one of the lady members. It would take a couple of months or so to do, and he asked for someone to volunteer to do it. Such a volunteer would have a chance of doing a real piece of original research work of value in solving one of the greatest of the Moon's problems.

The meeting was then adjourned until Tuesday, the 27th February 1912.

The Motions of the Planets.

BY DR. D. N. MULLICK, B.A., F.R.S.E.

The ancient astronomers included under the name of "planets," or "wanderers" not only bodies like Mercury, Venus and the other planets known to them (excluding the Earth) but the Sun and the Moon as well. For to these astronomers, not only Mercury, Venus, Mars, Jupiter and Saturn, but also the Sun and the Moon appeared to move in somewhat erratic paths, as compared with the heavenly bodies in general. Very simple observations were, indeed, enough to convince them that, whereas the majority of the heavenly bodies—the stars—move in paths in the heavens which remained unaltered from day to day, all appearing to be chained together by an invisible bond, the paths of these wanderers baffled all attempts at bringing them under any coherent law. Yet we have now as complete a knowledge of these as we have almost of any natural phenomena. Very simple observations are enough to assure us that the stars move in fixed circles whose planes are parallel to each other and perpendicular to a certain fixed line in space, all completing a cycle in a fixed period of time, called the siderial day. If the motion observed be real, we must suppose that all the infinite number of heavenly bodies were connected together in some mysterious way. If, on the other hand, the motion is only apparent, it may be simply explained as being due to the rotation of the Earth about an axis, fixed in direction in space. The latter hypothesis giving a very simple account of a complex phenomenon, gradually gained acceptance, though it was only in the last century that positive proof was forthcoming that the Earth had actually this motion of rotation.

Proceeding now to the motion of the "planets," it is obvious that the motions they are observed to possess must be due partly to the motion of rotation of the Earth. In order to take account of this, all that is necessary to do is to observe the motion of these bodies relatively to the stars, *i.e.*, their motion among the stars.

When this is done, it is found that the Sun's path in the celestial vault (irrespective of the Earth's diurnal motion) lies on a great circle in a plane inclined to the equator (*i.e.*, plane perpendicular to the Earth's axis) and the Moon's path is also a circle in a different plane, the paths of the planets proper still presenting the most baffling complexity.

The motions of the Sun as thus observed may again be either real or apparent. Arguments, into which I do not wish to enter, lead, however, to the positive conclusion that the

motion is apparent, that the Sun is really stationary or practically so and that the Earth is moving about the Sun. It follows thence that the Moon's motion cannot also be apparent but that she is really moving round the Earth.

Turning now to the planets, it is found that they appear sometimes to go forward (that is, in the same direction in which the Sun appears to move), sometimes to go backwards (in the opposite direction to that of the Sun), and sometimes to stand still. But all these complicated motions may be explained by supposing that they all move about the Sun in elliptic orbits, more or less inclined to the orbit of the Earth, that the Earth itself moves about the Sun in an elliptic orbit, and that the rates at which they severally move in their orbits are different, being connected, however, by a simple law [the third law of Kepler.]

On this simple scheme, we can not only explain completely the highly complicated motions of the planets, but the scheme itself is found to be deducible from the principle of universal gravitation.

Let us consider how this scheme can explain some of the peculiar features of planetary motion referred to above. We note in the first place that in accordance with Kepler's third law an inferior planet moves more rapidly round the Sun than the Earth. Therefore, when such a planet is between the Sun and the Earth, it will appear to move (say) from left to right (just as when two persons are going—one at 5 miles an hour and the other at 7 miles an hour, the latter will obviously go forward), while at the same time, the Sun will appear to go from right to left. On the other hand, when the Sun is between the planet and the Earth, both the planet and the Sun will *appear* to move from right to left. Therefore, also, while the planet is changing its direction, it will appear to be stationary.

The motions of the planets obey three laws, discovered by Kepler, by observation alone.

The first law may be thus stated: If a planet goes from P to T, in one day and from T to U the next day, then S being the Sun, the area S P T is equal to the area S T U. Now, if the area S P T is small, it is proportional to the product of S P^2 and the angle S P T. But S P, or the distance of the Earth from the Sun, varies inversely as the angular radius of the Sun, and the angle S P T is the change in the longitude of the Sun. Hence by observing the angular diameter and the change in longitude from day to day, the law can be verified in the *case of the Earth*. In the case of any other planet the reduction of observations will require a little more trigonometry, but the method is similar.

The second law states that these orbits are ellipses.

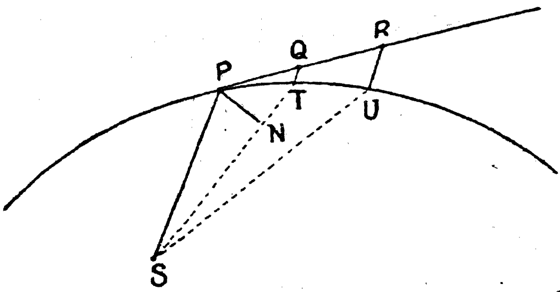
We have seen how S P varies. Representing it on any assumed scale and representing also the angles (changes in longitude) made by successive positions of S P, we can plot the curve traced out by P, if a sufficiently large number of observations shall have been made. This was what Kepler actually did and the paths were found to be ellipses.

The third law states that the squares of the periodic times vary as the cubes of the major axes or the greatest diameters of the elliptic orbits described by the planets.

Since the orbits are known, all that has to be done is to observe the time taken by the planets to go round the Sun. For this we notice that if the Earth goes round the Sun in y days it goes $\frac{1}{y}$ of the total circuit in one day; similarly, the planet goes $\frac{1}{p}$ of the circuit in one day if its periodic time is p, then it goes ahead of the Earth by $\left(\frac{1}{p}-\frac{1}{y}\right)$ of the circuit in one day. When it has gone ahead by a whole circuit, it will be in the same relative position to the Sun and the Earth as at the beginning. The interval therefore is $\frac{1}{\frac{1}{p}-\frac{1}{y}}=\frac{py}{y-p}$. This interval can be observed—for it is the interval between, say, two successive conjunctions, and hence p can be determined, since y, the number of days in the year, is known.

These laws seem, at first sight, to be too complicated to be of much use. It is remarkable, however, that they are all consequences of a single law—the law of universal gravitation. And we reach this grand generalisation—that all these complicated motions of the planets are due to an attraction (directed to the Sun), varying according to the law of inverse square of the distance or the force under which a planet P moves in its orbit is μ/SP^2 where S is the position of the Sun and μ, a constant (nearly) for all the planets.

Let P be the position of planet at any time moving in the



direction P Q. If there had been no action of the Sun, the

planet would have continued to move along P Q, and Q, R would have been its positions at t, 2t seconds after, *t* being small.

On account of the attraction of the Sun, however, directed along P S, it occupies positions marked T, U instead. In other words, the planet is displaced through Q T, R U, in the times t and 2t seconds. Since these displacements are due to a force acting along P S, very nearly, Q T, R U are parallel to P S, and the areas P S T, P S U are very nearly triangles. We have, accordingly, by Euclid, the triangle P Q S.

=the triangle P S T.
=Q S R.
=T S U.

That is, the areas P S T, T S U, are equal or the area described by the planet is proportional to time. Thus the first law of Kepler is seen to flow from the supposition that the motion of a planet is due to an attractive force directed to the Sun.

Again, if V is the velocity of the planet at P, P Q=Vt. and if p is the perpendicular from S on P^2Q.

We have P Q.p=Vt. p.

Which we have just proved proportional to *t*.

i.e., Vp=constant.

Calling this const. *h*, we have $V^2 = \frac{h^2}{p^2}$.

But the kinetic energy acquired by a particle is equal to the work done by the force producing the motion.

Now as the planet is displaced from P to T, T being a neighbouring point, the displacement may be considered to be made up of P N (perp. to S T) and T N. The first being perpendicular to the force along S T, produces no work. The work is, therefore, measured by F. T N, where F is the force at T.

If, then, U is the velocity at T, V being the velocity at a fixed point P,

$$\tfrac{1}{2}(U^2 - V^2) = -\frac{\mu}{ST^2}.\quad T\,N. = \mu\frac{SP-ST}{ST.\ SP.} \text{ very nearly,}$$

$$= \frac{\mu}{S\,T} - \frac{\mu}{SP.} \text{ very nearly;}$$

$$\text{or } U^2 = \frac{2\mu}{S\,T} + V^2 - \frac{2\mu}{SP.}$$

$$\text{But } U^2 = \frac{h^2}{P^2}$$

$$\therefore \frac{h^2}{p^2} = \frac{2\mu}{D} + V^2 - \frac{2\mu}{SP,}$$

where D = distance of the planet from the Sun at any point and p = perpendicular from the Sun on the direction of motion at that point.

But in a conic section,

$\frac{2}{D}$ is greater than, equal to, or less than $\frac{l}{p^2}$, where l is the semilatus rectum, according as it is an ellipse, a parabola or a hyperbola.

Hence, the path of a planet is a conic section where $h^2 = \mu l$ and it is an ellipse provided it is found to possess a suitable velocity at any particular point, that is, if V^2 is *less* than $\frac{2\mu}{SP}$, V being the velocity at a point P. As the body has always the same velocity, whenever it comes to the same position, it must have started at some unknown point of time with a certain definite velocity which was suitable for the description of the elliptic path.

The third law follows from the relations that have been obtained already, but it is unnecessary to trouble you with the analysis.

Note on a Brickwork Stage for a Siderostat.

BY W. HANLEY.

In deicding on the form of the stage for the siderostat we had to consider the ventilation of the adjacent building, and on this account it was settled to adopt the form sometimes used on railways for tank stages. This type of staging is economical in cost while providing ample base area.

In Bengal the pressure permissible on the ground may be taken as ½ to ¾ of a ton per sq. ft., but in order to avoid as far as possible any trouble from settlement, the pressure in the case of this stage was reduced to about ¼ ton per sq. ft. by floating the structure on a large base of concrete about 1 ft. thick.

The stage consists of 2 parallel rows of 3 columns of brickwork 2′—1″ × 1′—8″ each, tied at the bottom by segmental inverts so as to ensure even distribution of the weight, and at top by semicircular arches. It is hoped that this method of construction will prevent vibration. If, however, vibration

is noticed while walking about on top it will be possible to fill in the spaces between the area with brickworks and then fill up the interior with earth up to any height that may be found necessary.

The roof has been made in the usual way by jack arching and concrete filling, and in order to compensate for the thrust of the arch 5 tie bolts 1″ thick have been fitted at 3 ft. intervals. Under the siderostat the arch has been made twice as thick as in the rest of the roof, and in order to ensure the siderostat against movement due to the arch cracking from settlement or from the weight on the siderostat itself 4 rolled steel joists 4″ × 1½″ by 6 ft. in length have been built into the concrete.

In order to avoid having to provide independent access to the roof the stage had to be put close to the building so as to enable the operator to get at the instruments, etc., from the roof, and situated as it is in the re-entrant angle of the building, the width was practically limited to its present dimension. In order to provide sufficient room to move about all round the instruments a light gallery of planking carried on joists will be built as shown in the cross section.

In fixing the height two factors had to be considered. The structure had to be high enough to enable the siderostat to command a clear view all round over the top of the main roof and yet be not so much above verandah roof as to make it difficult of access.

The length of the tube and the angle at which it had to be placed was the other factor. At the time the design was made the actual height from ground to the centre of the reflector had not been fixed, but it was assumed to be 4 ft. The upper end of the tube will rest on a saddle of wood resting on a baulk timber built into the brickwork. This arrangement will allow of adjustments being made as required hereafter both vertically and horizontally.

To get the general direction of the longitudinal axis of the stage an approximated meridian line was laid down by direct observation on ursæ minoris with a theodolite. It was found, however, after the concrete was put down that there was a slight error in this line owing either to the shifting of the pegs by the workmen or to some errors in the instrument, or both combined. A new theodolite was borrowed for the occasion and a provisional meridian line obtained using the old peg. This line would have brought the centre line of the masonry 7 to 7½ inches to one side of the mean centre line of the concrete. By shifting the theodolite the meridian line and the centre line of concrete were eventually got to coincide as near as was practicable.

Extracts from Publications.

Note on the two main types of Cometary Development and their Variation with the Solar Distance. (*By J. H. Reynolds*).—At the March meeting of the Society I drew attention to the two principal types of cometary development.

The first type is that in which the tail is merely a continuation of the parabolic envelopes of the head, formed from matter projected from the nucleus towards the Sun; this may be termed the cylindrical type, and is associated with large comets near perihelion, such as 1910*a*. In the other type the tail is formed from streamers radiating from a point in the nucleus directly away from the Sun; this may be termed the conical type, and of this Morehouse's Comet was a conspicuous example.

From an examination of the Helwan photographs of Halley's Comet, it was evident that both types were represented in the series, the cylindrical type being developed when the comet was near perihelion at a distance of 0·5 to 0·6 R, and the conical type coming into prominence when the solar distance was greater than 0·8 R.

As it seemed, therefore, probable that the type of tail development depended on the solar distance, a preliminary examination of the photographic records of other comets was made by Mr. Knox Shaw and myself. Unfortunately these records are very incomplete, and usually only a few isolated photographs of each comet are available. At the same time the results were fairly consistent, and the following provisional classification was adopted, to which there were no marked exceptions:—

Solar distance under 0·6 R—Cylindrical type.

Do. 0·6 to 0·8 R—Intermediate, combining both the cylindrical and the conical types.

Do. over 0·8 R—Conical type.

The only series of photographs in the library of the Society comparable with the Helwan series of Halley's Comet were the Greenwich photographs of Morehouse's Comet. As, however, the perihelion distance of this comet was over 0·9 R, and the latest photograph in the library was taken over a month before perihelion passage, this series has no bearing on the point at issue, except that the conical form of tail was consistently shown.

Recently two comets have appeared which go far towards putting this provisional classification on a firm basis.

Beljawsky's Comet (1911*d*), photographed at Helwan at a solar distance of between 0·3 R and 0·4 R, showed distinctly the cylindrical type. Photographs of Brooks' Comet (1911*c*), taken by Mr. Longbottom at Chester, showed a well-developed conical tail, while the solar distance was 1·0 R and over. When near perihelion, at about 0·5 R, it appears visually to have developed the cylindrical type, and this is confirmed by photographs taken at that time.

[*Monthly Notices of the Royal Astronomical Society, Vol. LXXII No. 1.*]

Note on the Spectrum of Comet Brooks (1911c). (By the Astronomer Royal of Scotland).—The cameras were rotated so as to have the edge of the prism approximately parallel to the comet's tail, but it was not until the end of October that a definite tail could be traced in the spectra.

With the spar camera no trace could be found of duplicity in the knots, such as is recorded in the spectrum of Comet Morehouse (1908*c*), the brightest knot γ 467 being, in particular, noted as symmetrical and round. The knot γ 388 was very much flatter, and on one or two negatives gave the impression of a slight shading towards the violet.

With the other camera the knot γ 467 is distinctly double, the fainter image being on the violet side. None of the other knots showed signs of duplicity.

As early as September 8 a faint continuous spectrum could be traced, and this phenomenon was easily visible as the brightness of the comet increased. This comet differs in that respect from Comet Morehouse, in which the continuous spectrum was absent.

[*Monthly Notices of the Royal Astronomical Society, Vol. LXXII, No. 1.*]

The astronomical event of the last few weeks in my immediate circle has been the almost sudden death of Mr. W. T. Lynn, mentioned in the "Scientific News" column of last week. I make no apology for occupying space here in writing about a personal friend, for the deceased gentleman must have been known to many readers of this paper by his writings, if not by his personality. He had not been an immediate colleague of mine, because he left the Royal Observatory Staff, which he did chiefly from considerations of health, in 1880, a year or two before I joined; but for the last seven-

teen years I have received from him with unfailing regularity, about the first day of each month, at least one letter, if not more, for publication in the Observatory Magazine on some astronomic-historical subject of the type with which members of the British Astronomical Association will associate the name of Mr. Lynn. For thirty years he devoted himself to this kind of research, living in Blackheath alone, but not quite the life of a recluse, for he had relations and friends in the neighbourhood, at whose houses he was always welcome. During the last few years of his life he suffered from a troublesome complaint in his right arm, which might have caused some persons to give up writing; but Mr. Lynn went gamely on to the end, earning the respect which was shown by the attendance of a representative gathering at his funeral service.

The death-roll of astronomers for the year now coming to an end is not a very long one. Besides the name of Mr. Lynn, it includes those of Dr. Johnstone-Stoney; Mr. W. Coleman, of Dover, an amateur who made micrometric measures of double stars, several series of which are published in the Memoirs of the Royal Astronomical Society, and whose 8-in. telescope, by the way, was bequeathed to that Society, and is now being used by a well-known observer; Mr. Arthur Cotlam, one of the first secretaries of the British Astronomical Association; the Rev. Dunne Parker, of Stevenage; and another Fellow of the Royal Astronomical Society, Mr. Wegg-Prosser, of Hereford. As all these six gentlemen lived to well over seventy—the average of their ages at death was, in fact, above eighty years—more evidence is added in favour of the unusual longevity of astronomers.

[*English Mechanic.*

No Sermonising.—But Mr. Hollis's remarks this week about the longevity of astronomers has made me reflect, and, against my will, I am compelled to utter—to make you also reflect. Possibly it will be a chance for you. It is true that those who make the pursuit of knowledge their chief aim in life perpetually renew their youth. Their active minds disregard the creakings of their body machinery. They do not "drop like mellow fruit into the grave"; they disappear, leaving good influences and noble aspirations for others. The Goddess of Science sometimes claims a victim from among her votaries; but she is never merciless as is the Goddess of Pleasure. "Truisms" I hear some one mutter. Exactly. Very many lives have been ruined by the neglect of the commonest truisms.

[*English Mechanic.*

Scientific Optical Surface: Eyes Shining at Night.—Mr. H. N. Irving, in letter 672, raises the question of plate-glass *versus* cast and annealed discs for mirror-making. The question is by no means such a simple one as he appears to represent it. I hold no brief for either plate or cast discs, but plate is a favourite material with the great body of amateur mirror-makers, and in the interest of these very deserving and persevering workers, I should like to relieve their minds of fears which might be raised by the remarks of Mr. Irving and Mr. D. Booth.

In the first place, what is "plate-glass"? Many and various are the makes of it. Some kinds are sad rubbish from an optical point of view, though good enough for shop-windows. But the best sorts are of very high quality indeed, and in the perfection of their annealing and their freedom from veins and patches of unequal density, bubbles, and other flaws, compare very favourably indeed with the best cast discs. I have several large lenses which I have made from good plate-glass, and these are for the most part quite free from internal defects.

[*English Mechanic.*

Some Ideas about Mars.—In regard to Martian "Canals," two ideas of the past week are worth mentioning. One is that the shape of any object that is too small to be defined is necessarily round. Of course, this has been pointed out before, but without the guinea-stamp of authority which it now receives. But, as stated, it requires qualification. The law laid down was that, whether the object itself be round, square, or irregular, its telescopic image is round. This is quite true as long as the aperture of the telescope is circular. But a square aperture must produce square images, and a triangular one triangular images, and so on, the fact being that the shape of detail too small for definition is necessarily a function of the shape of the aperture.

The other idea was that Mars was shown to have a mean temperature below the freezing-point, and it was argued that therefore all the water on Mars was in the condition of ice, and that the "canals" could not be water-channels. Well, what we know of the temperature of Mars does not amount to much; but accepting the view that water is present on Mars, we are bound to accept also the Polar caps as deposits of snow, and snow at all implies that water evaporates somewhere else; and, further, we see that the Martian snow-caps melt entirely away now and again, which is definite proof that even the Poles of the planet are for a considerable period above the freezing-point.

[*English Mechanic.*

Memoranda for Observers.

Standard Time of India is adopted in these Memoranda.

For the month of March 1912.

Sidereal time at 8 p.m.

	H.	M.	S.
March 1st	6	36	36
,, *8th*	7	3	41
,, *15th*	7	31	17
,, *22nd*	7	58	53
,, *29th*	8	26	29

From this table the constellations visible during the evenings of March can be ascertained by a reference to their position as given in a Start Chart.

Phases of the Moon.

		H.	M.
March 3rd	Full Moon . .	4	12 P.M.
,, *11th*	Last Quarter .	1	26 A.M.
,, *19th*	New Moon . .	3	39 A.M.
,, *26th*	First Quarter .	8	32 A.M.

Meteors.

Date.	Radiant R.A.	Radiant Dec.	Character.
March 1-4 . .	166°	+4°	Slow, bright.
14th . .	250	+54	Swift.
18th . .	316	+76	Slow, bright.
24th . .	161	+58	Swift.
27th . .	229	+32	Swift, small.
March-May . .	263	+62	Rather swift.

The showers in the month of March are not likely to be very brilliant.

Planets.

Venus.—Is a morning star. Its position on the 15th March at 8 P.M. will be R.A. 21 hrs. 52 mts. 45 secs. Dec. 13° 45′ 32″ S. The time of its rising will be 4 hrs. 19 mts. A.M. on the 16th March.

Saturn.—The position of the planet on the 15th March at 8 P.M. will be R.A. 2 hrs. 58 mts. 13 secs. Dec. 14° 46′ 46″ N. The time of its setting will be 9 hrs. 30 mts. P.M.

Mars.—The position of the planet on the 15th March at 8 P.M. will be R.A. 5 hrs. 11 mts. 50 secs., and Dec. 25° 0′ 14″ N. The time of its setting will be 0 hr. 4 mts. A.M. on the 16th March.

Jupiter.—The position of this planet on the 15th of March at 8 P.M. will be R.A. 16 hrs. 55 mts. 3 secs. Dec. 21° 49′ 1″ S. The time of its rising will be 11 hrs. 35 mts. P.M.

Classes.

Astronomical Questions for Beginners.

The following questions have been drawn up for the benefit of those who are beginning the study of astronomy, and especially for those who are availing themselves of the classes organised by the Scientific Sub-Committee of the Society. Members should answer them and send their answers to the Director of Classes, who will then help them over any difficulties they may experience. The answers and the correspondence will not appear in the Journal but will be conducted direct with each member concerned. It is hoped therefore that members will not hesitate to make full use of Mr. B. N. Rakshit, the Director, and to communicate their difficulties to him so that he may assist them with their reading in a practical manner.

Very Elementary Questions.

(1) What are the right ascension and declination of the First Point of Aries ?

(2) What is the declination of the North Pole ?

(3) If the right ascension of a body is 25°, express it in time.

(4) The right ascension of a star on the equator is 8 hrs. 20 mts. ; find that of one which is also on the equator but 3 hrs. 40 mts. west of the first.

Harder Questions.

(1) What are right ascensions and declinations of the following points in the heavens :—

(*a*) Summer solstice, (*b*) Libra, (*c*) Winter solstice. Also what are the celestial latitudes and longitudes of these ponts ? Illustrate your answers by diagram.

(2) Assuming the latitude of Calcutta to be 225° N, what are the declinations of stars which never set and also of those which never rise above the horizon of Calcutta ?

(3) What stars describe great circles and what stars small circles on account of the diurnal rotation of the Earth on its axis ?

(4) Distinguish between a civil and an astronomical day. What time according to civil reckoning corresponds to 15 hrs. of 2nd January of astronomical reckoning ?

Notices of the Society.

Election of Members.

The attention of members is invited to Bye-Law No. 14, regulating the election of persons who desire to join the Society. It is hoped that those who are already members will induce others to join. Forms of application can be had from the Secretary, Mr. P. N. Mukherji.

Change of Addresses.

It is particularly requested that when members change their addresses, they will kindly notify the new address to the Secretary. The omission to do this is likely to cause the loss of the Journals and other communications.

Telegraphic Address.

The address of the Society has been registered at the Telegraph Office, Calcutta. Telegrams should be addressed "Astronomy," Calcutta.

The Library.

A subscription list exists and several members in Calcutta have subscribed and enabled the Council to make a beginning with the Library. Other members outside Calcutta, however, have not, except in one or two cases, yet come forward, and as the Library will be one of the most important adjuncts of the Society, and will be available to members both in and out of Calcutta, those who have not yet done so are invited to help the Society in making progress with this important branch of the work. Suggestions as to useful books for the Library will also be welcomed by the Librarian.

A number of books have already been received and can be borrowed by members in accordance with the Bye-Laws.

The books available can be ascertained from the Assistant Librarian and a catalogue will be issued shortly. The reading room of the Society in the Imperial Secretariat is now opened for the use of members daily from 5 to 7 P.M. except on Wednesdays and holidays and from 3 to 5 P.M. on Saturdays unless that day is a holiday.

The Journal.

The following charges have been fixed for back numbers of the Journal:—

For members.—Per copy 12 annas ; per volume Rs. 5.

The Star Chart.—As. 12 a copy.

For non-members.—Rs. 1-8 per copy.

The Star Chart.—Rs. 2 a copy.

Subscriptions.

Subscriptions for the current session fell due on 1st October 1911. Those who have not paid in their subscriptions are requested to remit them to the Treasurer at their convenience.

Papers for Meetings.

It is requested that drawings which accompany papers for reproduction in the JOURNAL may be made with Indian ink on white paper. This will insure a clear reproduction.

List of Instruments.

With a view to enable the Council to obtain a knowledge of the instrumental equipment of the members, it is requested that those members who possess any instrument suitable for astronomical work will kindly send details to Director of Instruments of its kind, size and power.

Programme of Work for the Session.

Sub-Committee.—The Council have appointed a Scientific Sub-Committee consisting of the Scientific Secretary and the Directors of Sections. This Sub-Committee will direct the observational and educational work of the Society under the Council, and will consider in detail and take steps to introduce practical work. To begin with, the following are to be considered and taken up :—

(*a*) Instructions and Classes for members who are beginners.

(*b*) Observational Work for those members who will embark on it.

(*c*) Practical Classes for members in Calcutta.

(*d*) Public Lectures in Calcutta.

Members will shortly receive communications from the Sub-Committee regarding these matters.

Meetings for the Session 1911-12.

ORDINARY MEETINGS.

1912.	1912.
March 26th.	May 28th.
April 30th.	June 25th.

The meetings will commence at 5 P.M. and, until further notice, will be held in the Imperial Secretariat (Treasury) Buildings.

Addresses of Officers.

Owing to inconvenience which has arisen from addressing the Officers of the Society at their private address, it has been decided to receive communications on the business of the Society in future as follows :—

	To
Money orders or letters containing money or cheques.	U. L. BANERJEE, ESQ., Office of the Accountant-General, Bengal, 3, Koila Ghat Street, CALCUTTA.
All other communications	(*Name*) ....Esq. (*Designation*) ....of the Astronomical Society of India, Imperial Secretariat (Treasury) Buildings, Calcutta.

It is requested that communications may be addressed accordingly.

Officers and Council.

FOR THE SESSION 1911-12.

(1) *President* . . . H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.

(2) *Vice-Presidents* . . (1) COL. S. G. BURRARD, R.E., C.S.I., F.R.S.

(2) J. EVERSHED, ESQ., F.R.A.S.

(3) SREE RAJA A. V. JUGGA RAO BAHADUR GARU, F.R.A.S., F.A.I., F.R.M.S., F.A.S. & C.

(4) H. H. THE MAHARAJA RANA BAHADUR SIR BHAWANI SINGH, K.C.S.I., F.R.A.S.

(3) *Secretary* (*Scientific*) . DR. E. P. HARRISON, PH.D.

Do. (*Business*) . P. N. MUKHERJI, ESQ., M.A., F.R.E.S., F.S.S.

Treasurer . . . U. L. BANERJEE, ESQ., M.A.

Directors of Sections—

Lunar Section . . H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.

Meteor Section . . P. C. BOSE, ESQ.

Variable Star Section . LIEUT.-COL. LENOX-CONYNGHAM, R.E., F.R.A.S.

Instrumental Director . S. WOODHOUSE, ESQ.

Director of Classes . . B. N. RAKSHIT, ESQ.

Librarian . . . C. T. LETTON, ESQ.

Editor . . . . J. J. MEIKLE, ESQ.

OTHER MEMBERS OF THE COUNCIL.

MRS. PERCY BROWN.
J. C. DUTT, ESQ., M.A., B.L.
H. B. HOLMES, ESQ.
F. W. HOWSE, ESQ.
A. T. MITRA, ESQ., M.A.
J. C. MITRA, ESQ., M.A., B.L.
C. W. PEAKE, ESQ., M.A.
SARODA CHARAN MITTER, ESQ., M.A., B.L.
W. J. SIMMONS, ESQ.
C. K. SIRCAR, ESQ., C.E., M.S.A., M.S.E.

The Journal of the

Astronomical Society of India.

Vol. II.] SESSION 1911-1912. [No. 5.

Report of the Meeting of the Society held on Tuesday, the 27th February 1912.

H. G. Tomkins, C.I.E., F.R.A.S., *President*, in the Chair.

P. N. Mukherjee, M.A., F.S.S., *Secretary*.

The Secretary having read the minutes of the last meeting which were duly confirmed, the following presents to the Society were then announced and a vote of thanks was accorded to the respective donors :—

Notices of the Royal Astronomical Society, Vol. LXXII, No. 2.

Journal of the British Astronomical Association, Vol. XXII, No. 3.

Bulletin of the Astronomical Society of Bercelona, Dec. 1911.

Ri Vista Di Astronomia for January 1912, Anno. VI, No. 1.

Monthly Weather Review of the Alipore Observatory for Sept. 1911.

Bijnan, Vol. I, No. 1.

"Prithivir Puratatta" by Mr. B. B. De.

The election of the following members at the last meeting of the Council was then confirmed :—

The Hon'ble Mr. P. C. LYON, C.S.I., I.C.S.

Mr. W. A. LEE, F.R. MET. S.

„ C. B. SEN, B.A.

„ H. SUR, B.A.

„ W. D. McLAREN.

The President then announced that a telescope which had been given to the Society by Dr. Harrison had arrived and would be put upon the roof of the building of the Imperial Secretariat Building for the benefit of the members who might have occasion to use it for purposes of observation. A notice would be circulated when the instrument was ready for use. It had to be slightly altered to make it correspond to the latitude of Calcutta. He next announced that the second public lecture under the auspices of the Society would take place at the Town Hall on the 1st of March 1912 on the subject of the Moon. He asked members to let their friends know that these lectures were free and to bring their friends with them. He hoped to see a large number present.

Another matter which the President wished to bring to the notice of members was that at the suggestion of Mr. Evershed, one of the Vice-Presidents, the Council had registered the address of the Society at the Head Office of the Telegraph Department. The registered address of the Society was "Astronomy, Calcutta."

The President then called on those members present who had not done so to sign the Roll of the Society and he then formally admitted them.

The President.— The first paper on our list this evening is a mathematical one. We had one of this class last month which we greatly enjoyed and we have another this evening. I would ask Mr. Ghose to read his paper on Lunar Measurements.

Mr. Ghose then read a most interesting paper on the measurement of the heights of lunar mountains.

The President.—In the case of mathematical papers it is extremely difficult to give on the black-board all the steps by

which the results are arrived at and to put all that one wishes to say in mathematical form. It is only possible in dealing with papers of the kind to indicate generally what has been done, and to learn the details by closer study by members when they have the paper in print. This, I am sure, we shall many of us look forward to doing with Mr. Ghose's interesting paper. While listening to what Mr. Ghose has said, however, it struck me that he brought out clearly some of the principles on which he worked, and particularly the method by which he got his heights by measuring the distance of the first appearance of a peak as a bright spot from the line joining the cusps. Regarding the other method described by him, of course the altitude of the Sun is merely a form of putting the angle at which the Sun is shining at the extremity of the shadow of the mountain. If we have this and the length of the shadow we can get the exact height of the mountain. About measuring this shadow, however, there is a difficulty which arises from the point of view from which we measure it. Supposing one mountain threw a shadow directly towards us, we should then not be able to measure it at all. It could be directly measured only if the shadow were thrown normal to our line of sight. Any position between them would result in a foreshortening of the shadow and our measurement would be too small in every case. As a matter of fact this occurs, and not only so, but the perspective differs at every lunation depending on the libration of the Moon. We therefore have to allow for this in our measurements, and Mr. Ghose, I notice, has devoted a large portion of his paper to this. It is a part of the problem which I personally shall examine with interest, and I do not doubt that many others will do the same.

There may be some questions that members may like to ask with regard to this paper.

Col. Burrard.—Regarding the measurement of the shadow, what radius is adopted? I take it that the surface of the Moon varies in distance from the centre, some parts being high and some low. Again, suppose we take the case of the Sun at mid-day in Calcutta; it will throw a shadow due north. How do you take account of this in measuring the height of the mountain?

The President.—I think that Mr. Ghose takes the mean surface with the mean radius of the sphere. Naturally, one must have some level from which to measure these mountains. On the Earth we have sea-level, but on the Moon

there are no seas, and consequently the heights have to be measured above the plain on which the shadow falls.

Col. Burrard.—It seems to me you are measuring the length of the shadow at the place on which it happens to fall, and if the foot of the mountain happened to be on a plateau, as, for instance, Thibet, the result would not be a measure comparable with those of other heights.

The President.—You mean that the height would be shortened. The height of the mountain would be so many thousand feet above the level of its foot. This would also make a slight difference in the Moon's radius for the purposes of the calculation. Could Mr. Ghose tell us what he has adopted ?

Mr. Ghose.—I have taken a mean radius.

The thanks of the meeting were then awarded to Mr. Ghose for his interesting paper.

Mr. Banerjee next read a portion of a paper he was writing on the Habitability of the Planets.

The President.—One or two points struck me while Mr. Banerjee was reading his paper. The first of these was the method adopted of expressing the power of a telescope as bringing the Moon or a planet within so many miles of the Earth. This has always seemed to me to be a very inaccurate gauge to the power of an instrument. Doubtless, if there were no atmospheric conditions to be taken into account, it might convey some meaning, but it is perfectly certain that what is seen with an instrument said to bring the Moon to a distance of 150 miles is very different from what would actually be visible if the Moon were placed at that distance and viewed with the instrument. The more scientific way, and the way which conveys the power of an instrument at once to anyone accustomed to use one, is to express it in aperture and focal length, and then say that magnification of a given number of diameters was used. Another point was the rotation of Venus. Mr. Banerjee adopts the long period of 224 days, but as a matter of fact the question whether the period is that time or only about 23½ days is one of the most debated in that branch of astronomy. There is a good deal of evidence for the shorter period and one or two observers have quite recently held that view. The doubt has arisen from the extreme difficulty of detecting a definite feature on Venus.

Mrs. Voigt.—I thought there was an atmosphere around the planet.

The President.—Which planet are you referring to ?

Mrs. Voigt.—Mercury. Am I not right in thinking that an atmosphere was visible at the time of the transit of Mercury over the Sun some years ago ?

The President.—Perhaps Col. Burrard could tell us. I am not sure whether he was present at the observations of the transit of either Mercury or Venus.

Col. Burrard.—I was not present, but I do not think there was any evidence. I don't know, however, that it is denied that there is an atmosphere round the planet.

The President.—Perhaps you are referring to what is known as the black drop which occurs at the moment of contact ?

Mrs. Voigt.—Yes ; I think I am.

The President.—That is simply an optical phenomenon and not connected with an atmosphere on the planet. There is an atmosphere on Jupiter and Venus, on Mars very little, and on Venus probably very dense. It is very difficult to discern any features on the last planet.

I may perhaps make one other remark in connection with the statement in Mr. Banerjee's paper that life exists on every planet. I do not think it is probable that beings such as we know on the Earth exist on any of the planets. Take the planet Neptune. It is generally supposed to be not yet cool. Uranus is not very different. I do not think there is direct evidence to indicate life on any planet, though it is speculated that it may exist on Mars and perhaps Venus.

The thanks of the meeting were then accorded to Mr. Banerjee for his paper.

The President then showed a series of fine photographs of the spectrum of the Sun taken at the time of a total eclipse. The spectra were taken at different times during the eclipse and were of the Sun at mid-eclipse, the flash spectrum and some others. They were taken by Mr. Evershed of the Kodai Kanal Observatory and kindly sent for the Society to see.

The photographs were greatly admired and a hearty vote of thanks was accorded to Mr. Evershed for sending them.

The President.—I think we are very fortunate in having a Vice-President who sends us these slides.

The meeting was then adjourned until the 26th March 1912.

Measurements of Heights of Lunar Mountains.

By S. C. Ghosh.

To Galileo is due the discovery that the surface of the Moon is covered with mountains and valleys. According to this astronomer the luminous points which are seen isolated near the border of light and darkness, on the lunar surface, are the summits of mountains which from their heights catch the sunlight first, and appear as stars like the bright spot P in the diagram I. As time passes the bright spot becomes larger as the light extends lower down the mountain side until the terminator reaches and passes it.

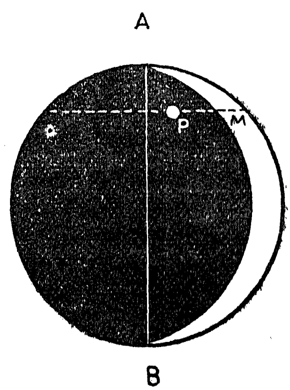


Fig. I.

Now P is the projection of the bright summit of a mountain peak on the visible disc of the Moon. Let us measure the distance of P with a micrometer in a direction PM perpendicular to the line of cusps, as well as the distance AB between the cusps. Then PM is the projection of a tangent to the sphere parallel to the Sun's rays, and therefore making with PM an angle equal to the complement of the Moon's angle of elongation. This is illustrated in Figure II in which

O represents the centre of Moon and the lines S′O, SP and S″E are parallel rays from the Sun.

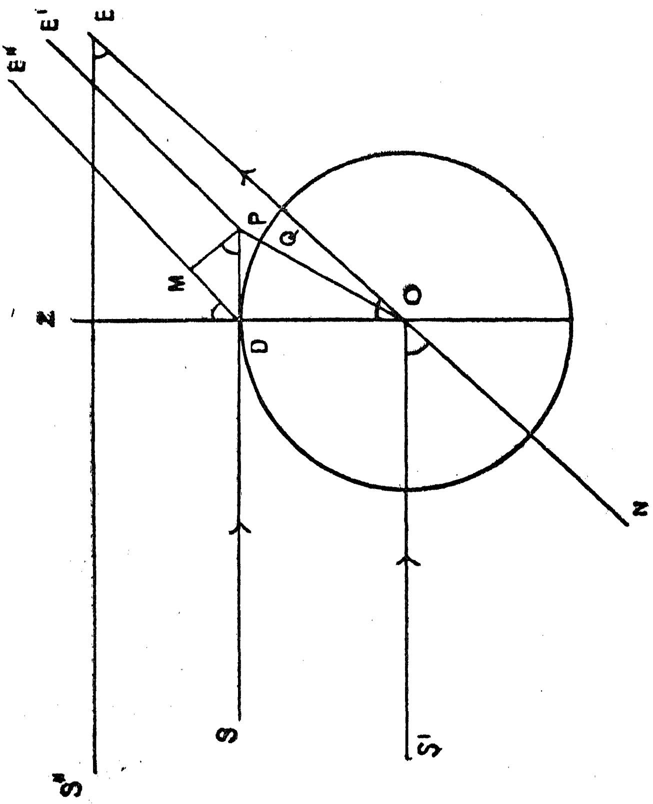


Fig. II.

The Moon's distance being only about $\frac{1}{400}$ of the Sun's, the line S″E is, for practical purposes, parallel to S′O. Therefore the angle S″EO = the complement of ∠ ZOE = the complement of ∠ ZDM = the complement of ∠ DPM.

Now putting down the height of the Moon (PQ) $=x$,

the radius of the Moon $\left(\frac{AB}{2}\right)=OD=r$

$S''EO = \theta$, and,

the distance P M $= d$

We have

$$PD = \frac{PM}{\text{Cos MPD}} = \frac{d}{\text{Sin } \theta} = d \text{ Cosec}$$

and $PO^2 = DO^2 + DP^2$

$$\text{or } (r + x)^2 = r^2 + d^2 \text{ Cosec}^2 \theta$$

$$\text{or } r^2 + x^2 + 2\,r\,x = r^2 + d^2 \text{ Cosec}^2 \theta$$

$$\text{or } \quad \frac{x^2}{2r} + x = \frac{d^2 \text{ Cosec}^2 \theta}{2r}$$

$$\text{or } \quad x = \frac{d^2 \text{ Cosec}^2 \theta}{2r} \text{(very nearly).}$$

$$\therefore \quad x = \left(\frac{d}{2r}\right)^2 2r \text{ Cosec}^2 \theta$$

$$= m^2 \; 2r \text{ Cosec}^2 \theta$$

Where m is the ratio of the distance PM to the line of cusps AB, as observed by the micrometer, and θ the Moon's angle of elongation.

Galileo observed the distance PD to be equal to $\frac{1}{20}$th part of the diameter.

Therefore according to the above formula we find the height of the mountain

$$= \frac{PD^2}{2r} = \left(\frac{PD}{2r}\right)^2 2r = \left(\tfrac{1}{20}\right)^2 2r$$

$$= \frac{2153}{400} \text{ miles} = 5{\cdot}37 \text{ miles, or } 28{,}000 \text{ feet,}$$

which is a height equal to that of the highest summits of the Himalayan range. As the Moon's diameter is only $\frac{3}{11}$ of that of the Earth, we see that her mountains are comparatively very much loftier.

This remarkable result has been fully established by the accurate measurements of Mädler, who adopted the method of measuring the length of the shadows and the distance within the illuminated portion of the surface in which was the peak. This method is more accurate and is explained below.

Placing the cross-wire of the micrometer so as to be parallel to the line of cusps, the length of the shadow of the mountain is measured; next, the distance of the summit of the mountain from the terminator or border of illuminated surface is measured; and then, moving the micrometer into a position at right angles to the former, the distance of the mountain from the cusp of the Moon is determined. Converting these from micrometer revolution

into arc and correcting for refraction, when necessary, the resulting distances may be put down as follows :—

σ = the length of the shadow.

T = the distance from the terminator.

α_o = the distance from the cusp.

Now let us obtain the following date for the time of observation :—

θ_o = the geocentric longitude of the Sun.

θ = the geocentric longitude of the Moon.

β = the geocentric latitude of the Moon.

p_o = the horizontal parallax of the Sun.

p = horizontal parallax of the Moon.

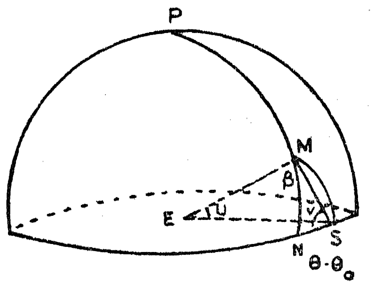


Fig. III.

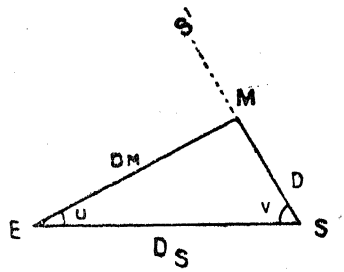


Fig. IV

Let E be the Earth,
,, S ,, Sun is the ecliptic and
,, M ,, Moon in the celestial sphere.

Then we have in the spherical triangle MNS,

$MN = \beta, \qquad NS = \theta - \theta_o, \qquad \angle MNS = 90°.$

Let us also put down

u = angular distance at the centre of the Earth between the Moon and the Sun.

v = angular distance at the Sun between the Earth and the Moon.

dm = the distance of the Moon from the Earth.

ds = the distance of the Sun from the Earth.

d = the distance between the Moon and the Sun.

Then we have from the spherical triangle MNS.

$$\text{Cos } u = \text{Cos } \beta \text{ Cos } (\theta - \theta_o) \qquad (1)$$

and from the triangle EMS

$$\frac{\sin u}{d} = \frac{\sin v}{dm}$$

$$dm^2 = ds^2 + d^2 - 2\, d.\, ds.\cos v.$$

$$= ds^2 + dm^2 \frac{\sin^2 u}{\sin^2 v} - 2.\ dm\ ds \sin u \cot v$$

$$\frac{dm^2}{ds^2} = 1 + \frac{dm^2}{ds^2} \cdot \frac{\sin^2 u}{\sin^2 v} - 2.\frac{dm}{ds} \sin u \cot v$$

$$\frac{dm^2}{ds^2}\left(1 - \frac{\sin^2 u}{\sin^2 v}\right) = 1 - 2.\frac{dm}{ds}.\ \sin u.\ \text{Cot}\ v$$

$$\frac{dm^2}{ds^2}[1 - \sin^2 u(1 + \cot^2 v)] = 1 - 2.\frac{dm}{ds} \sin u \cot v$$

$$\frac{dm^2}{ds^2}\cos^2 u = 1 - 2.\frac{dm}{ds} \sin u \cot v + \frac{dm^2}{ds^2} \sin^2 u \cot^2 v$$

$$\therefore\quad 1 - \frac{dm}{ds} \sin u \cot v = \frac{dm}{ds} \cos u$$

$$\text{or}\quad 1 = \frac{dm}{ds} \sin u \cot v \text{ (nearly)}$$

$$\therefore\quad \tan u = \sin u \frac{dm}{ds} = \sin u \frac{dm}{er} \cdot \frac{er}{ds} \text{(where}$$

er is the radius of the Earth).

$$= \sin u \tan p_o \cot p. \text{————} (2)$$

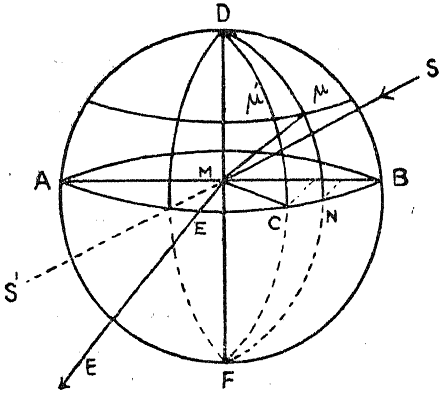


Fig. V.

Let A D B F be the Moon's disc visible to the observer and perpendicular to M E the line to the Earth.

Let S M be the direction of the Sun. Then D C F is the limit of the illuminated surface and is perpendicular to M S.

Therefore, $\angle$ B M C $= 90° - \angle$ BMS $= \angle$ EM S′ where MS′ is the elongation of the line S M,

$= u + v$ (see Figure IV).

$\therefore$ If we call the angle E C $= \omega$, then

$$\omega = 90^\circ - (u + v) \qquad (3)$$

[$u + v$ being obtained for equations (1) and (2)]

Let us suppose that D μ NF is the great circle passing through the mountain at μ and let us call the arc μ N $= \nu$. This is obtained from the following equation :—

$\sin \nu = \frac{s' - a_0}{s'}$ where s' is the Moon's semi-diameter.—(4)

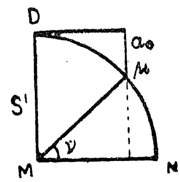


Fig. VI.

Let us represent the angular distance between the great circles passing through the mean terminater and the mountain by i. Then CN $= i$ and EN $=$ EC $+$ CN $= \omega + i$

Now projecting the arc ECN on the disc ADBF we have the projection of EN $=$ the projection of EC plus projection of CN or s$'$ $(\omega + i)$ $=$ s$'$ sin $\omega +$ projection of $\frac{\mu\ \mu'}{\cos \nu}$

$$[\because \quad \frac{\mu\ \mu'}{\sin D\mu'} = \frac{CN}{\sin Dc} \text{ and}$$

$$\sin D\, \mu' = \cos \nu \text{ and } \sin D\, c = 1]$$

$$= s' \sin \omega + \frac{T}{\cos \nu} \qquad (5)$$

[Where T is the observed distance of the mountain from the terminator and is therefore the projection of $\mu\,\mu'$ on ADBF].

Now the height of the Sun above the horizon at μ is computed as follows :—

Let ϕ be the altitude of the Sun at μ

Then $90^\circ - \phi =$ zenith distance of the Sun at μ

Let us take a point S$'$ in Fig. VII, so that CS$' = 90^\circ$. Then SMS$'$ is a diameter passing through the Sun and the Moon's

centre at M. Let S μ s' be a great circle passing the mountain at μ. Then $S\mu s' = 180°$ and $\mu\ s = 90° - \phi$

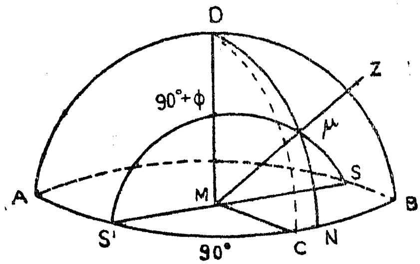


Fig. VII.

$\therefore$ $S'\mu = 90° + \phi$
$\therefore$ in the spherical triangle $S'\ \mu\ N$
$\cos \mu\ s' = \cos S'N \cos N\ \mu$ ($\cos S'\ N\ \mu$ being $= o$)
or $\cos (90° + \phi) = \cos (90° + i) \cos \nu$.
or $\sin \phi = \text{Sin}\ i \ \cos \nu$ ... ———————— (6)

When ϕ is known, since i and v are known from equations (4) and (5).

Now the length of the shadow as measured (σ) is not its actual length since what is seen is the projection of the actual shadow on the disc ADBF

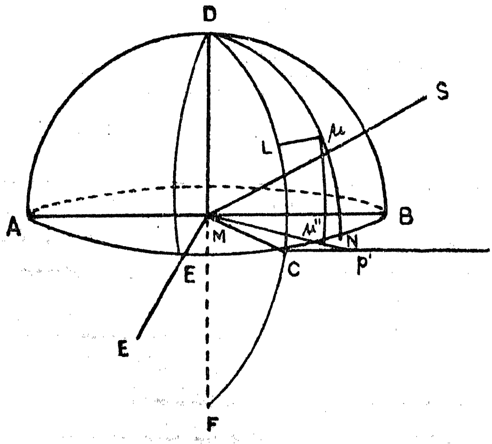


Fig. VIII.

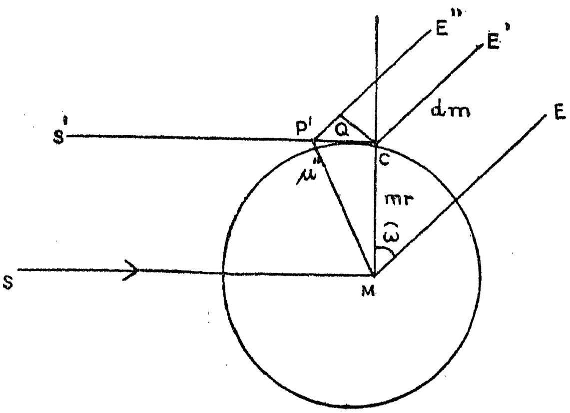


Fig. IX.

The plane of the shadow (L μ) is the central plane perpendicular to the plane D C F. (Fig. VIII). If $\mu\,\mu''$ be a plane perpendicular to the plane ACB, we have actual length of shadow

$$=L\mu$$
$$=c\mu''$$
$$=cP' \quad \text{ultimately.}$$

Now, $CQ = P'C \cos \omega$

$$\therefore \frac{CQ}{dm} = \frac{P'C}{dm} \cos \omega$$

$$= \frac{c\,\mu''}{Mc}\,\frac{Mc}{dm} \cos \omega = \frac{L\mu}{mr}\,\frac{mr}{dm} \cos \omega$$

where mr = radius of the Moon and dm = the distance of the Moon from the Earth.

$$\sigma = \sigma' s' \cos \omega$$

$$\text{or } \sigma' = \frac{\sigma}{s' \cos \omega} \qquad \text{———} \qquad (7)$$

The height of the Sun above the horizon at μ (ϕ) and the true length of the shadow (σ') being now known, the height H of the mountain can be computed as follows :—

Let M μ z be the zenith at μ, P the top of the mountain and S the Sun.

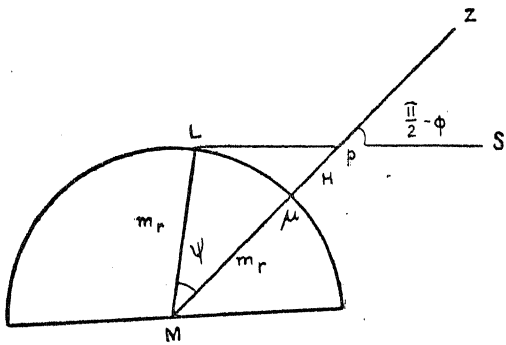


Fig. X.

Then $\angle$ SPZ $= 90° - \phi$

If we call the angle at the Moon's centre between the summit of the mountain and the end of the shadow $= \psi$

Then in the triangle L M p we have

$$\frac{\sin \psi}{\mathrm{L}\,p} = \frac{\cos \phi}{\mathrm{L\,M}}$$

$$\text{or } mr \sin \psi = \mathrm{L}\,p \cos \phi$$
$$= \sigma' \, mr \cos \phi \text{ (ultimately)}$$

$$\therefore \sin \psi = \sigma' \cos \phi \quad \text{———} \quad (8)$$

$$\text{Also, } \frac{\mathrm{H} + mr}{\sin (90° - \phi + \psi)} = \frac{mr}{\sin (90° - \phi)}$$

$$\frac{\mathrm{H}}{mr} + 1 = \frac{\cos \phi - \psi)}{\cos \phi}$$

$$\text{or H} = \left\{ \frac{\cos (\phi - \psi)}{\cos \phi} - 1 \right\} mr \quad \text{———} (8)$$

Mädler took the heights of upwards of 1,000 lunar mountains: of these six exceeded 3·62 miles (or 19,000 feet) in height and twenty-two exceeded 3·01 miles (or 16,000 feet), which latter is the height of Mont Blanc above the sea level.

The lunar mountain, called Dörfel, is situated near the south pole in the midst of a large plain and has a height of 4·75 miles (or 25,000 feet).

The lunar mountain, called Newton, is an annular crater and rises to a height of 4·54 miles (24,000 feet): the cavity of the crater lying below the general surface of the Moon.

Habitability of the Planets.

BY U. L. BANERJEE.

When we cast our eyes on the different planets wending their periodical course round the Sun, a question naturally arises in our mind, whether the Earth is the only planet in our system in which the Creator has centred all the animals and planets of the world, making human beings an image of himself. This is a question which can only be solved by direct observations with most powerful telescopes and other instruments at our command. But there is a limit to the magnifying power of the telescope. To have a cognisable view of a being like ours on any planet, the object must be brought at least to a distance of 10 miles from us. But the largest telescope hitherto constructed has not been able to bring an object on the Moon, which is the nearest body in our solar system, to a less distance than 150 miles. Attempts are being made to increase the magnifying power every day, but the more this power is developed the greater becomes the disturbance in the outlines of the images, owing to the constant motion of our atmosphere, through which the observations are made. Direct observation of beings like ours on the different planets by earthly instruments thus seems a hopeless task. But this should not deter us from investigating into the physical conditions of some of the planets, and see in what respect these planets seem to be adapted to be the abode of life like ours. The physical conditions of our Earth are in many respects similar to those of other planets, and it does not seem unreasonable to suppose that there might be creatures like ours or somewhat like ours on other planets of our solar system. Mr. H. C. Wilson has recently read a paper on the "Life in Other Worlds" before the Astronomical Society of the Pacific, and came to the conclusion that there is not a single planet in our solar system on which a life like ours can possibly exist. But one hesitates to accept such a sweeping conclusion, when we on our own planet find life flourishing under different conditions of temperature and pressure. Travelling over the Earth from the polar regions to the torrid zone, one finds in the severe cold of the arctic regions, with its perpetually frozen seas, long summer days and winter nights and scanty vegetation, life abounding in hundred different forms. Esquimaux there feel themselves comfortable with seal flesh and do not hanker after dainty vegetable dishes. On the other hand, in the tropical zone, with its scorching heat, absence of rain and fearful hurricanes,

one meets with even more abundant forms of life. Mountain summits clad with perpetual snow, and deep seas with temperature some degrees below zero, and pressure of several atmospheres are not devoid of living creatures. This is not all. As the conditions of the Earth change from age to age, different forms of life appear more adapted to the altered circumstances and old forms disappear; thus making our globe a permanent abode of successive forms of life. Thus the mammoths and vegetables of the pre-historic age have gone and their places have been taken by new types of animals and vegetables. So that one cannot help concluding that although the physical and other conditions are different in different planets, it is not impossible to have life of different stages of development and more suited to their conditions living therein.

Let us now examine the physical conditions of each of the planets and see in what respect they resemble or differ from our Earth.

Passing outward from the Sun, the first planet we meet with is Mercury. It circles round the Sun in 88 days. Its distance from the Sun varies according to the eccentricity of its orbits, the maximum distance being 43,000,000 miles and minimum distance 29,000,000 miles. When nearest to the Sun it gets 9 to 10 times more light and heat than we do, and when furthest from it the light and heat are reduced by more than one-half. It circles round the Sun at an average speed of 29 miles per second. Schiaparelli is of opinion that the planet rotates upon its axis in the same time that it revolves round the Sun, and this has since been verified by Lowell's Observations at Flagstaff, but there is a difference of opinion about this as according to Schroter it seems to rotate round its axis and the Mercurial day is a few minutes longer than ours. Its equator is said to be much more inclined towards its plane of revolution than the Earth, making its days and nights almost equal in all places and at all times. Its density cannot be accurately determined owing to the absence of any satellite; it has, however, been roughly calculated by the perturbation of Euche's Comet when in its neighbourhood that its density is not more than one-sixth greater than our Earth. As its diameter is 3,000 miles, its weight is $\frac{1}{15}$ of that of the Earth. The force of gravity on its surface is such that a pound weight of ours would weigh less than 7 ounces on Mercury.

If the equality of the periods of rotation round its axis and revolution round the Sun is to be believed, it would show the same face to the Sun like our Moon, and there will on the one hemisphere be an eternal day and on the other an everlasting

night. There would thus be 9 to 10 times the heat on one side raising its temperature to an enormous extent, while on the other side there would be as low a temperature as of the space. There may be a temperate zone about 45° on the other side, owing to librations. If on the other hand the rotation theory round its axis is to be believed, there would not be much variation in the Mercurial seasons at any particular spot like our Earth, but there would be a difference of climate in different parts of the planet making it habitable like our Earth. Of course everything depends upon the presence of atmosphere and water on its surface. Astronomers largely differ in this respect as its atmospheric conditions cannot be satisfactorily examined with the telescope owing to its proximity to the Sun. The recent investigations of Mr. Percival Lowell show that there are no signs of clouds nor of any atmospheric envelope. If so, there is a great doubt about the planet being habited by beings like our own.

The planet next to Mercury is Venus. It has a year of 224 days, 17 hours, and its distance from the Sun is somewhat less than $\frac{3}{4}$ths of that which separates us from the Sun, being 67,000,000 miles. It travels nearly 22 miles per second. Its day is about 35 minutes shorter than ours and its globe somewhat smaller than the Earth's. According to some eminent astronomers, its axis is inclined only 15° to the plane of her orbits, causing thereby an existence of different seasons somewhat resembling ours. Gravity on its surface is nearly equal to the gravity on the Earth. It has got an atmosphere far more intense than ours. The diameter of Venus is about 7,700 miles, against 7,918 miles of the Earth's diameter. Its mass is $\frac{3}{4}$ of that of the Earth or $\frac{1}{425,000}$ of that of the Sun. Its density is about ·850 of that of the Earth. It would weight 4·81 times as much as a globe of water of the same size. The force of gravity on its surface is slightly less, as a body there falls about 13 feet in a second against 16 feet on the Earth's surface.

It will thus be seen that in matters of size, situation, density, and the length of her seasons, as well as in the shape of its orbit and in the amount of light and heat it receives from the Sun, it resembles the Earth more than any other planet. We might therefore expect conditions here suitable for life like ours. There is, however, some difference of opinion among astronomers as to the period of rotation round its axis. In 1888 Schiaparelli came to the conclusion that Venus, like Mercury, keeps the same side always towards the Sun, rotating once in exactly the same time in which it revolves round the Sun. Mr. Lowell's recent observation also confirms this view.

If the theory of equality between rotation and revolution periods be accepted there would be very little libration in longitude owing to the nearly circular nature of its orbit, and the conditions of the side exposed to the Sun, and that on the other side of it would be even more contrasted and constant than Mercury. Prof. Lowell is of opinion that the constant atmospheric currents would carry away the moisture from the sunward hemisphere and deposit it in the form of snow and ice on the other side. This process kept up from age to age would make one part altogether devoid of water and the other part full of perpetual ice; and such extreme rigours of climate would make the planet quite unsuitable for a habitation of beings like those on the Earth.

But this theory is not accepted by the general body of astronomers, and a rotation period of a few minutes less than ours is ascribed to it. As such there is an alteration of day and night on different parts of the globe. But as its axis is inclined only 15° to the plane of its orbit, a number of singular and somewhat complicated relations are presented. Further, the arctic regions extend within 15° of its equator while the tropics extend within some degree of its poles—so that two zones larger by far than the temperate zones of our Earth belong both to the arctic and tropical regions. An inhabitant of the polar regions has therefore to endure the extremes of heat and cold. During the summer the Sun circles continually close to the point overhead, so that every day a continuous stream of light and heat of nearly two-fold intensity is found on its surface. Only for a short time in autumn and in spring does the Sun rise and set in the polar regions. A spring or autumn day like one of our days at those seasons lasts about 12 hours, and the Sun attains at noon a height of only a few degrees above the horizon. Then comes the terrible winter season lasting about 3 of our months. The Sun approaches the horizon at the hour corresponding to noon, and though it does not show its disc, it brightens up the southern skies with a cheerful twilight. During the greater part of the long night the Sun does not approach within many degrees of the horizon; an intense darkness prevails. These alternatives of extreme rigour of polar winter and summer heat are of course too much for human beings like ours.

The conditions of equatorial regions are also different from ours. Here are two summers corresponding to the spring and autumn of the polar regions. At these seasons the Sun rises overhead each day and the weather corresponds to what prevails in our tropical regions. But between these seasons the Sun passes alternately to the northern and southern skies;

it attains no great elevation, travelling always in a small circle close round the northern pole. During winter the Sun is above the horizon only for a short time each day and is always close to the south, attaining only an elevation of a few degrees at noon. In such regions the change of climatic conditions are so rapid that no races subsisting upon our earth could possibly endure them comfortably.

But astronomers are yet far from finally accepting the above inclination of the axis. If that inclination somewhat resembles that of the Earth, there is every reason to believe that the physical conditions resemble those of the Earth, and the planet becomes quite suitable for habitation by creatures which exist on the surface of our planet.

Extracts from Publications.

On September 16 and 17, 1896, any one observing the Sun with the naked eye would have seen upon it a long, straight "canal," as straight, as regular, as hard and sharp as any "canal" that Mr. Lowell ever saw upon Mars. (Three photographs of the Sun on September 16, 1896, on different scales, shown on the screen). A field-glass would, however, have shown it as a chain of round dots, and a good telescope as a succession of small spots of great complexity and beauty. What did the apparent straightness of the group as seen with the naked eye mean? Simply that the observer had not a sufficient magnifying power to show the great irregularity of the details. Yet the very best circumstances under which any one has seen Mars is only relatively equivalent to seeing the Sun or Moon with a magnifying power of 3 or 4 diameters. Where is the reasonableness of assuming that because we are at present not able to detect irregularities in certain markings upon the planet Mars, that, therefore, no possible improvement in our means of vision will ever show any details there? The attitude is the more unreasonable because Schiaparelli himself, long before Mr. Lowell took up the study of Mars, had already succeeded in seeing some, at least, of the canals as knotted, somewhat sinuous, lines. And, in more recent years, the most experienced observers of the planet and the most favoured in the power of the telescopes at their disposal, and in the situation of their observatories, have abundantly confirmed Schiaparelli's

work in this, and have found the "canal" not hard uniform "ruled lines," but full of minute irregularities without a suggestion of artificiality.

Journal of the British Astronomical Association, Vol. XXII, No. 3,

On Meteor.—I would point out, in the first instance, that no valuable instruments are required before commencing. A quick eye capable of locating the position of a meteor at the beginning and ending of its course, and of judging its direction in relation to known stars in the vicinity, is the most essential equipment. In recording the visible path it will be found very useful to have a wand in the hand and to project it upon the track; this will greatly facilitate the estimation of its direction. Of course, the eyes would be directed towards that part of the heavens from which the meteors were expected to radiate; these particular parts for various seasons are known to all, and it is not necessary to dwell further upon this point. When a meteor has been observed, the time, magnitude of the meteor, beginning and ending of its course, duration of flight, colour and character should be noted as quickly as possible in a book with separate columns for these details. Each observer will naturally use his own methods of abbreviation under these several particulars, so that as little time as possible may be lost in recording the flight. Many meteors might be missed if the attention were taken up for a long time in noting down the various details. The paths of meteors as recorded are, of course, often rough eye-estimates of position, so that a certain amount of error will generally occur. In determining the radiant, on which we shall speak immediately, the mean error will vary considerably, according to the individual's exactness.

Let us suppose that an observer has noted the apparent directions of a number of meteors on any night, and he pencils their paths out on a celestial globe or on a star chart. He will notice that their paths are of very different lengths, and that they show various velocities. But when the lines showing their tracks are produced backwards, they will be found to converge more or less approximately to a point. Of course, all the lines will not so converge, but a sufficient number will be found to show that this convergence is not merely fortuitous, but that there must be some connection between the mass of meteor tracks on the globe or chart. The determination of the radiant, as the place where these lines intersect is called, is an important part of the work of those who study meteors. It is from this part of the heavens that they radiate, and the

name of the constellation in which this point appears is assigned to the shower which comes from it.

Journal of the British Astronomical Association, Vol. XXII, No. 3.

Members of the staff of the Paris Observatory have lately determined the difference of longitude between that place and Bizerta in Tunis by the help of wireless telegraphy. This is not the first time that astronomers have availed themselves of the Hertzian waves for such a purpose, but, remarks the *Athenæum*, the distance of 800 miles makes the achievement remarkable. Signals sent up from the Eiffel Tower at regular intervals were heard in telephone receivers and timed at Tunis and at the Paris Observatory, and similarly, signals sent from the wireless installation at Bizerta were heard in both places. By this means the clocks at the two stations where observations were being made were compared. A telegraphic longitude determination always gives as a by-product a value for the speed of the electric current, and the account of this work in the "Competes Rendus" states that the time of transmission of the Hertzian wave between Paris and Bizerta was in the mean 0·007S., which gives a value of the velocity, as was to be expected, of the same order as that of light.

[*English Mechanic.*

Lecturing at the Royal Institution last week on "The New Astronomy," Professor A. W. Bickerton described the manner in which, he believed, new stars are caused by solar collisions. The collision of two suns, he said, as reported in the *Times*, resulted in the formation of a third body. If two dead suns came into collision they would burst into flame. The collision would take about three-quarters of an hour. In each case the collision would take the same time, as the colliding bodies would get up a velocity proportionate to their size. Then there would flash out a brilliant star, which would become a permanent body. The effect of a complete collision of two gaseous suns would be to make a new Sun. Such collisions were not accidental. They did not occur at random. Included among a number of agencies tending to develop such collisions was gravitation. Before suns collided, they fell towards each other and got up speed for hundreds of years. The tremendous speed thus developed was stopped suddenly in the colliding parts and converted into heat. Thus in about an hour a new star was born, explosive force expanded it, and it swelled out its diameter at a speed of millions of miles an hour. The sudden flare-up of a light thousands of

times the brilliancy of the Sun had induced astronomers to imagine that a collision of suns had caused the phenomena. The spectra observed, however, were absolutely inexplicable to them because they had overlooked the third body, the new star. The lecturer contended that the appearance of Nova Persci, a new star so brilliant that nothing equal to it had appeared for 300 years, was explained by his theory. Nova Persci was ten thousand times as brilliant as the Sun.

[*English Mechanic.*

At the January meeting of the Royal Astronomical Society, after the reading of the rather sensational telegram from America, mentioned in last week's "Scientific News" column, about the breaking up of Saturn's Ring—a suggestion which did not receive very much support from Mr. Phillips, who had been observing the planet rather carefully, and told us he had seen no signs of dissolution—the Fellows present listened with more interest to a paper by Mr. H. C. Plummer on the subject of stellar movements and distances, which is rather a frequent topic now-a-days. The problem that astronomers are setting themselves is to find, besides the parallax, the actual direction of motion of stars in space, and their velocity in miles per second, the data at command for the solution of the problem being the observed motion of the star on the celestial sphere (*i.e.*, its proper motion), the velocity in miles per second in the line of sight, and the distance of the star, but the knowledge of the last two quantities is sparse, because their determination, being somewhat difficult, has been effected for comparatively few stars. Therefore, in default of complete information, those who make investigations of this kind generally begin with some assumption, and then find out how well it fits with known facts. Mr. Plummer had some new material in the shape of determined velocities in the line of sight of stars of type A and B, which had been put in his hands by Professor Campbell, of Lick, and for certain reasons he made the assumption that stars move parallel to the plane of the Milky Way, and then combining this assumption with the observed proper motion of the individual stars, and with their radial velocity, was able, by very simple geometry, to deduce values of the star's distance or parallax. A table of the hypothetical parallaxes of groups of these stars so determined was the main result of the paper. Many of them agreed quite reasonably with the parallax determined by more direct methods, thus giving support to the original assumption, and it also appeared from examination of the figures, that there is a group of stars about twenty in number, most of them well-known stars, in different parts of the sky as seen from the Earth, which move

with parallel and equal motion, this being the same as that of the stars in Taurus which were said by Prof. Boss, not long ago, to form our family.

[*English Mechanic.*

The Movements of the Stars.—Turning to the position of the stars, Professor Schuster said that irrespective of the daily motion due to the rotation of the Earth, we did not notice in ordinary circumstances any change in their distribution. But motions and velocities which were enormous were going on in space. Arcturus moved at the rate of something like 500 miles a second. The distance it travelled could be detected with telescopes in a few weeks, and in 450 years the distance travelled would appear about equal to the diameter of the Moon. The velocities of the stars generally ranged from ten to thirty miles a second. A systematic investigation of their movements gave some remarkable results. For a considerable time it had been known that the Sun and the whole Solar System was moving through space with a velocity of about 15 or 16 miles a second. Recently it had been discovered that the stars could be divided into two groups, which, with reference to the position of the whole stellar system, moved in exactly opposite directions. These movements of the Sun and the stars through space were comparatively small, and no marked difference could be seen in a couple of years. But in, say, ten million years, the position of the stars would have altered altogether. Ten million years was really a very short time. (Laughter). The first crust of the Earth was formed certainly more than a hundred million years ago—according to some authorities a thousand million years ago—and our present stellar system was therefore no indication whatever of what was seen when the Earth first began to solidify.

In addition to the two main "drifts" he had mentioned there were other movements of groups of stars. In the case of Pleiades, for example, the great majority of the stars—and in addition to the six or seven visible to the naked eye in this group there were over 2000 visible to the telescope—were moving in the same direction and with the same velocity as though they were rigidly connected. Five of the stars of the Great Bear group also moved in the same direction, and with the same velocity, and several other stars, including Sirius and one close to Capella, moved with them. Each of these stars gave out forty times as much light as the Sun, and each was the same distance from us—940 miles on the scale.

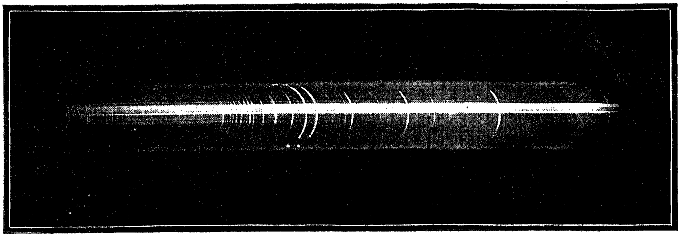
The Evolution of a Star.—The composition of the stars, or at any rate of their surfaces, was determined by spectrum analysis. By their spectra the stars could be arranged, roughly, in four groups. The first showed mainly hydrogen. The second had a marked resemblance to the Sun, and showed the presence of a great many metals, notably iron. The third and fourth showed metallic oxides and carbon compounds. The hydrogen group could be subdivided, for it included one class of spectra which showed helium. The theory had been formed that these different spectra did not indicate that the stars contained different substances, but merely that they were in different stages of development. It was conjectured that there was a kind of evolution going on, and that as the stars gradually cooled, the hydrogen was absorbed, and the metals appeared on the surface. The theory was very plausible. Coupling it with the discoveries as to the star "drifts," one found that the stars of the earlier type—the helium stars—deviated less from the general direction of their group than the older stars; the solar type and they in turn deviated less than the third and fourth groups.

In conclusion Professor Schuster said it might be asked "what is going to happen ultimately?" Few questions were more puzzling. One would imagine that when stars were "drifting" and some were moving more rapidly than others, they would gradually sort themselves out.

The two main streams ought ultimately to get past each other and separate, so that in one part of the heavens we should have only stars moving in one direction and in another part only stars moving in the opposite direction. But at present there seemed to be no indication of anything of the kind.

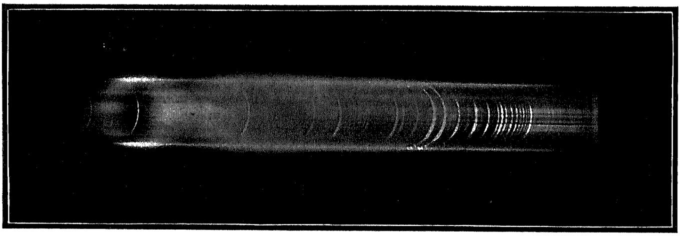
[*English Mechanic.*

On the day when this letter is published the Gold Medal of the Royal Astronomical Society will be presented to Mr. A. R. Hinks, one of the honorary Secretaries of the Society, and Chief Assistant at the Cambridge Observatory, for his determination of the Solar Parallax from observations of Eros. Everybody knows that when the small planet Eros was discovered in 1898, and it was realised that it would be only about thirty million miles from the Earth at the end of the year 1900, an international campaign was started to utilise this fine opportunity of finding the scale of dimensions of the Solar System. The photographs were taken according to a plan laid down in conference, and then, after a preliminary trial, Mr. Hinks proposed to Mr. Loewy, who was taking the lead in the organisation, that he (Mr. Hinks) should finish



No. 1, FLASH SPECTRUM AT SECOND CONTACT.

No. 2, SPECTRUM AT MID-ECLIPSE.



No, 3, SPECTRUM OF CHROMOSPHERE.

Photographs of Solar Spectra

taken by Mr. J, Evershed, F.R.A.S., at Talnai, India, on January 22nd, 1898.

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1912

the work and deduce the solar parallax. The photographs taken at Greenwich were reduced, and a value of the parallax determined under the direction of Sir William Christie, then Astronomer Royal; but most of the other co-operating observatories entrusted their photographs, or their visual observations, to Mr. Hinks, who has derived from the photographs 8·807″ as the value of the Solar Parallax, and 8·806″ from the micrometric measures, and for this work he deservedly receives this high honour from the Royal Astronomical Society. He has already been honoured in France, for the Paris Academy of Sciences last year awarded him the Leconte Prize for the same work.

A parallax of 8·806″ corresponds to a mean distance of the Earth from the Sun of 92,830,000 miles, so that if we say roughly that the Earth is 93 million miles from the Sun we are not far wrong; but we are fully justified in saying more correctly that it is ninety-two million nine hundred thousand, for all recent direct determinations cluster about 8·80″, which corresponds to that length. The final result of the Greenwich determination abovementioned was given as 8·800″ with a possibility of its being a little larger. A variation of 0·01″ in the parallax corresponds to 100,000 miles in the distance. It will be understood that astronomical observation gives only the angle, and to deduce from it the distance of the Sun in miles, it is necessary to use a value of the radius of the Earth's equator. In finding the above figures Colonel Clark's second value has been used; but an early determination of the size of the Earth differing much from this would have caused an alteration, if it had been used, of only about twenty thousand miles on the Sun's distance.

[*English Mechanic.*

Memoranda for Observers.

Standard Time of India is adopted in these Memoranda.

For the month of April 1912.

Sidereal time at 8 p.m.

	H.	M.	S.
April 1st	8	38	19
,, *8th*	9	5	55
,, *15th*	9	33	31
,, *22nd*	10	1	6
,, *29th*	10	28	42

From this table the constellations visible during the evenings of April can be ascertained by a reference to their position as given in a Star Chart.

Phases of the Moon.

			H.	M.	
April	*2nd*	Full Moon	... 3	35	a.m.
,,	*9th*	Last Quarter ...	... 8	54	p.m.
,,	*17th*	New Moon	... 5	10	p.m.
,,	*24th*	First Quarter ...	... 2	17	p.m.

Meteors.

	Date.	Radiant. R. A.	Radiant. Dec.	Character.
April	20th—23rd	189°	−31°	Slow, long.
,,	20th—21st	261	+36	Swift, bluish white.
,,	20th—22nd	271	−2	Swift, streaks.
,,	20th—25th	218	−31	Slow, long paths.
,,	30th	291	+59	Rather slow.

Planets.

Venus—Is a Morning Star. On April 15th at 8 p.m. its position will be R. A. 0 hr. 15 mts. 53 secs. Dec. 0°-2′-18″N. The time of its rising will be 4 hrs. 16 mts. a.m. on the 16th April.

Saturn.—The position of the planet on the 15th April at 8 p.m. will be R. A. 3 hrs. 11 mts. 44 secs. Dec. 15°-48′-19″ N. The time of its setting will be 7 hrs. 44 mts. p.m. on the 15th February.

Mars.—The position of the planet on the 15th April at 8 p.m. will be R. A. 6 hrs. 24 mts. 23 secs. Dec. 25°-7′-18″ N. The time of its setting will be 11 hrs. 14 mts. p.m. on the 15th April.

Jupiter.—The position of this planet on the 15th April at 8 p.m. will be R. A. 16 hrs. 55 mts. 39 secs. Dec. 21°-48′-33″ S. The time of its rising will be 9 hrs. 34 mts. a.m. on the 15th April.

Moon.

A partial eclipse of the Moon will take place on the 2nd of April 1912. The following are the Calcutta times of the different phases :—

	H.	M.	
First contact with the penumbra	1	48	a.m.
First contact with the shadow	3	19	a.m.
Middle of the eclipse	4	8	a.m.
Last contact with the shadow	4	56	a.m.
Last contact with the penumbra	6	28	a.m.

The magnitude of the eclipse is nearly ·2, considering the Moon's diameter to be unity.

Sun.

A central eclipse of the Sun, invisible in Bengal, will take place on the 17th April 1912. The approximate limit below which it will not be visible in any part of India is latitude 25° N.

Notices of the Society.

Election of Members.

The attention of members is invited to Bye-Law No. 14, regulating the election of persons who desire to join the Society. It is hoped that those who are already members will induce others to join. Forms of application can be had from the Secretary, Mr. P. N. Mukherji.

Change of Addresses.

It is particularly requested that when members change their addresses, they will kindly notify the new address to the Secretary. The omission to do this is likely to cause the loss of the Journals and other communications.

Telegraphic Address.

The address of the Society has been registered at the Telegraph Office, Calcutta. Telegrams should be addressed "Astronomy, Calcutta."

The Library.

A subscription list exists and several members in Calcutta have subscribed and enabled the Council to make a beginning with the Library. Other members outside Calcutta, however, have not, except in one or two cases, yet come forward, and as the Library will be one of the most important adjuncts of the Society, and will be available to members both in and out of Calcutta, those who have not yet done so are invited to help the Society in making progress with this important branch of the work. Suggestions as to useful books for the Library will also be welcomed by the Librarian.

A number of books have already been received and can be borrowed by members in accordance with the Bye-Laws.

The books available can be ascertained from the Assistant Librarian and a catalogue will be issued shortly. The reading room of the Society in the Imperial Secretariat is now opened for the use of members daily from 5 to 7 p.m. except on Wednesdays and holidays and from 3 to 5 p.m. on Saturdays unless that day is a holiday.

The Journal.

The following charges have been fixed for back numbers of the JOURNAL :—

For members.—Per copy 12 annas ; per volume Rs. 5.

The Star Chart.—As. 12 a copy.

For non-members.—Rs. 1-8 per copy.

The Star Chart.—Rs. 2 a copy.

Subscriptions.

Subscriptions for the current session fell due on 1st October 1911. Those who have not paid in their subscriptions are requested to remit them to the Treasurer at their convenience.

Papers for Meetings.

It is requested that drawings which accompany papers for reproduction in the JOURNAL may be made with Indian ink on white paper. This will insure a clear reproduction.

List of Instruments.

With a view to enable the Council to obtain a knowledge of the instrumental equipment of the members, it is requested that those members who possess any instrument suitable for astronomical work will kindly send details to Director of Instruments of its kind, size and power.

Programme of Work for the Session.

Sub-Committee.—The Council have appointed a Scientific Sub-Committee consisting of the Scientific Secretary and the Directors of Sections. This Sub-Committee will direct the observational and educational work of the Society under the Council, and will consider in detail and take steps to introduce practical work. To begin with, the following are to be considered and taken up :—

(*a*) Instructions and Classes for members who are beginners.

(*b*) Observational Work for those members who will embark on it.

(*c*) Practical Classes for members in Calcutta.

(*d*) Public Lectures in Calcutta.

Members will shortly receive communications from the Sub-Committee regarding these matters.

Public Lectures.

The series of three Public lectures in the Town Hall has been completed. The lecturers were COL. BURRARD, R.E., C.S.I., F.R.S., Mr. H. G. TOMKINS, C.I.E., F.R.A.S., and DR. E.P. HARRISON, PH.D., and the subjects were "The Earth as a Planet," "The Moon" and "The Planet Mars." The lectures which were largely attended will be published in a separate volume as a special publication of the Society, and each member will shortly receive a copy free. The price to non-members will be Rs. 3.

Meetings for the Session 1911-12.

ORDINARY MEETINGS.

1912.	1912.
April 30th.	June 25th.
May 28th.	

The meetings will commence at 5 p.m. and, until further notice, will be held in the Imperial Secretariat (Treasury) Buildings.

Addresses of Officers.

Owing to inconvenience which has arisen from addressing the Officers of the Society at their private address, it has been decided to receive communications on the business of the Society in future as follows :—

	To
Money orders or letters containing money or cheques.	U. L. BANERJEE, ESQ., Office of the Accountant-General, Bengal, 3, Koila Ghat Street, CALCUTTA.
All other communications	*(Name)* ....Esq. *(Designation)* ....of the Astronomical Society of India, Imperial Secretariat (Treasury) Buildings, Calcutta.

It is requested that communications may be addressed accordingly.

Officers and Council.

FOR THE SESSION 1911-12.

(1) *President* . . . H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.

(2) *Vice-Presidents* . . (1) COL. S. G. BURRARD, R.E., C.S.I., F.R.S.

(2) J. EVERSHED, ESQ., F.R.A.S.

(3) SREE RAJA A. V. JUGGA RAO BAHADUR GARU, F.R.A.S., F.A.I., F.R.M.S., F.A.S. & C.

(4) H. H. THE MAHARAJA RANA BAHADUR SIR BHAWANI SINGH, K.C.S.I., F.R.A.S.

(3) *Secretary (Scientific)* . DR. E. P. HARRISON, PH.D.

Do. (Business) . P. N. MUKHERJI, ESQ., M.A., F.R.E.S., F.S.S.

Treasurer . . . U. L. BANERJEE, ESQ., M.A.

Directors of Sections—

Lunar Section . . H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.

Meteor Section . . P. C. BOSE, ESQ.

Variable Star Section . LIEUT.-COL. LENOX-CONYNGHAM, R.E., F.R.A.S.

Instrumental Director . S. WOODHOUSE, ESQ.

Director of Classes . . B. N. RAKSHIT, ESQ.

Librarian . . . C. T. LETTON, ESQ.

Editor . . . . J. J. MEIKLE, ESQ.

OTHER MEMBERS OF THE COUNCIL.

J. C. DUTT, ESQ., M.A., B.L.
F. W. HOWSE, ESQ.
A. T. MITRA, ESQ., M.A.
J. C. MITRA, ESQ., M.A., B.L.
C. W. PEAKE, ESQ., M.A.
SARODA CHARAN MITTER, ESQ., M.A., B.L.
W. J. SIMMONS, ESQ.
C. K. SIRCAR, ESQ., C.E., M.S.A., M.S.E.
W. A. LEE, ESQ., F.R. MET. S.
MISS ALICE MCLEOD.

The Journal of the Astronomical Society of India.

VOL. II.] SESSION 1911-1912. [NO. 6.

Report of the Meeting of the Society held on Tuesday, the 26th March 1912.

MR. W. J. SIMMONS, *Chairman.*

MR. P. N. MUKERJEE, M.A., F.S.S. } *Secretaries.*
DR. E. P. HARRISON, PH.D. }

On the assembling of the meeting Mr. Simmons said that owing to the absence of Mr. Tomkins, the President, and the Vice-President (Colonel Burrard) on tour, it devolved on him to take the Chair that evening according to the rules of the Society. He then asked the Secretary to read the Minutes of the last meeting, which were then read and confirmed. The following presents to the Society were then announced by the Secretary, and a vote of thanks was accorded to the donors :—

1. Monthly Notices of the Royal Astronomical Society, Volume LXXII, No. 3.
2. Journal of the British Astronomical Association, Volume XXII, No. 4.
3. Memoirs of the British Astronomical Association, Volume XVIII.

4. Bulletin of the Astronomical Society of Barcelona for January and February 1912.
5. Journal and Transactions of the Leeds Astronomical Society for 1909 and 1910.
6. Revista Di Astronomia for February 1912, Anno. VI, No. 2.
7. Monthly Weather Review of the Alipore Observatory for October and November 1911.
8. The Observer's Hand-Book for 1912, published by the Royal Astronomical Society of Canada.
9. Les Progres Recents De L'Astronomie (IV—Annee. 1910).
10. The Collegian, No. 2.
11. "Bijnan," Volume I, No. 2.

The election of the following members at the last meeting of the Council was then confirmed :—

1. The Hon'ble Sir Frederick William Duke, K.C.I.E., C.S.I., I.C.S.
2. Lady Duke.
3. The Hon'ble Mr. Justice H. L. Stephen, C.V.O.
4. Mr. H. C. Greenwood.
5. ,, G. W. C. Brady.
6. ,, Evan A. Evans.
7. ,, George Pires, M.R.C.S., L.R.C.P. (London), D.P.H.
8. ,, Kumud Nath Mukerji, M.A.
9. ,, Jasoda Nanda Sen, M.A.
10. ,, C. V. Raman, M.A.
11. Dr. Birendra Nath Ghosh, L.M.S.

The Chairman next invited those of the newly-elected members who were present to come up and sign the Roll, which they did and they were then formally admitted to the Society.

The Chairman.—We make a slight change in the order of the items of business. First will be the reading of a short note prepared by Mr. Ghosh on the Measurement of the Lunar Mountains with reference to certain questions raised by Colonel Burrard at the last meeting.

In the absence of Mr. Ghosh the paper was read by Mr. C. V. Raman, M.A.

The Chairman.—The paper which has just been read is now open to discussion, and we shall be very glad if there are any questions which members present may put or ask.

As no remarks are forthcoming, I would ask you, Ladies and Gentlemen, to thank Mr. Ghosh for these notes and Mr. Raman for having kindly read them.

A vote of thanks was then accorded.

The next item taken up was a paper by Mr. Banerjee on the Habitability of the Planets.

In calling on Mr. U. L. Banerjee to read his paper on the Habitability of the Planets, the Chairman observed that the subject possessed great interest for many people. There had been numerous writers on this topic, many of whom were divines. He would name Kepler, Huygens, Bishop Wilkins, Arago, Tom Paine (who touched on it in his Age of Reason), Andrew Fuller, a Baptist theologian, and one of the founders of the Baptist Missionary Society, which had a branch in Calcutta, Dr. Chalmers, a leader in the Free Church Movement of 1843, Chambers in his Vestiges of the Natural History of Creation, Professor Whewell, Dr. Brewster, Professor Lowell and Alfred Russel Wallace. With these remarks as an introduction he would ask Mr. Banerjee to read his paper.

Mr. Banerjee then read his paper.

The Chairman announced that the paper was now open to discussion and he hoped that as many of the members as could do so would join in the discussion.

The Chairman.—Perhaps Dr. Harrison will favour us with his views on this very interesting subject, especially as he is quite fresh from his lecture at the Town Hall.

Dr. Harrison said he had made a slight mistake in the course of his public lecture in the Town Hall the other day in speaking of some pumping arrangements to force the water from the poles through the canals. But this is not necessary, as the propelling force is derived from the rotatory force of the planet.

Mr. Lee.—I would like to ask a question which arises about the position of the canal on the planet. It seems an extraordinary thing to allow a canal to run from the South Pole to the North Pole and from thence back to the Equator.

Mr. Banerjee.—The markings on the surface of the planet show that the canals run from one pole to another through the Equator.

Mr. Raman.—I do not quite understand how a current can be running in one direction and another under it in another direction.

Mr. Banerjee.—This is possible if the width and depth of the canals be large enough to allow of convection currents to set in, as is the case with the gulf streams on the surface of the Earth.

Mr. Raman.—What about the depth ?

Mr. Banerjee.—We have not sufficient information, but as the canals could be seen by the telescope we may guess that it is not inconsiderable.

Mr. Raman.—If you had a canal as wide and as deep as you suppose, you would never be able to fill it.

Mr. Banerjee.—There is no difficulty in filling up the canals with water considering the quantity of water on the surface of the planet.

Mr. Raman.—Is there any vegetation on the planet ?

Mr. Banerjee.—The change of colour on the surface of the planet along with the development of the body of the canals with the melting of polar caps leads the astronomer to think that there is vegetation on the planet, which flourishes with the advent of the summer.

Mr. Lee.—What is the thickness of the polar cap ?

Dr. Harrison.—40 degrees in summer and 4·5 in winter.

The Chairman.—Are there any further remarks to be put ?

Mr. Raman.—If it is a fact that the planet is inhabited, what kind of life exists on it ?

Mr. Banerjee.—We cannot actually define what kind of life exists, but it is certain that the planet is not barren like the Moon. When the physical conditions of the planet are similar to those of the Earth, we may expect some sort of life like ours existing on the planet. Dr. Harrison admits the life of vegetation on a planet.

The Chairman.—Is there anyone who would like to say anything further ? It is a fact that where there is light there must be eyes to see it. We find certain signs on the Earth to convince us that there is life on it, and if we find the same signs on the planets, they tell us there is life on a planet.

Mr. Raman.—What do you mean by habitability of a planet ?

Mr. Banerjee.—When we talk of the habitability of a planet we mean that there is life on it. It may not be habited by human beings like us for the present, but the physical conditions are such that it may be suitable to human habitation in time.

Before proposing a vote of thanks to Mr. Banerjee, the Chairman said that he would like to make a few remarks himself. He had at the outset referred to the large number of writers who had dealt with the question of the habitability of other planets. As might have been expected under the circumstances, numerous opinions and arguments had been advanced by these writers. He thought, however, that their arguments could be classed under three or four heads. Some had dealt with the subject on the *a priori* method. With regard to these he said all *a priori* arguments had to be used with caution and viewed with suspicion. Others again had adopted what might be termed the metaphysical argument. He would mention as a concrete example of this class of argument that it was used by those who argued that where there were objects of sense there must be sentient beings, or where there was light there must be eyes to see it. These writers assumed much and often argued in a circle. Then came a third class who adopted the analogical argument, which might also in this discussion be termed the astronomical argument. These writers had a wide range of analogical cases furnished by our Earth, and he himself considered the analogical argument was the strongest that could be used. He would mention some of the analogies he had in view. They were practically the cases employed by Mr. Banerjee in his paper. There was first the analogy that all the planets derive their light and heat as we do from the Sun. Then they all had an annual revolution which involved changes of seasons, such as we have on this Earth. Next there was the diurnal revolution which gave other planets the same phenomena of day and night which we enjoy. Some of the planets had clouds, which obviously indicated the existence of aqueous vapour, and therefore of water. Dr. Harrison had referred to one of Professor Lowell's observations of Mars when he detected clouds of what Lowell considered to be not aqueous vapour, but dust floating in the Martian atmosphere. It was now, the Chairman believed, widely accepted that dust must exist in an atmosphere before aqueous clouds would be formed, but in Mars a huge mass of dust had been detected floating in the air, but without having condensed into aqueous vapour. Finally, we now know that the same elements with which we were familiar on this Earth exist in other planetary bodies.

He, however, held that analogous cases must not be selected on only one side of the question. There were other analogies which he submitted should not be ignored. We had extremes of heat and of cold on our planet. In the cold of the Arctic zones and the wide regions around Siberia we met with life, but it was almost confined to mosses and stunted plants. In deserts like Sahara we had extremes of heat; the day temperature of the sand in Sahara rose to 150° F., and it fell at night to below freezing-point. The life forms of these deserts were limited to euphorbias, acacias, and cacti. An occasional camel trotted across the scene, but it was under human guidance, and, unless the desert killed it, did not stop there. He is of opinion such analogies should not be neglected. What he felt was that perhaps unconsciously those who argued for life forms in other planets really had the higher types of animal life in view; their arguments almost suggested that there was a Public Works Department in Mars. He would remind the members that Professor Lowell's views were not universally accepted, though we could not lose sight of the fact that Lowell had made a special study of Mars through many years of close and strenuous work. Then again the argument from analogy itself must be kept in view. It did not establish more than a probability. It might be a strong one, but it did not amount to an absolute demonstration. Bishop Butler, the Great Master of this class of argument, had laid down that probability was the very guide of life, and therefore when we considered these analogical arguments we must not pass them by lightly nor ignore their force. Finally he held the view that the problem of the habitability of the other planets could not be settled by mere argument. We must have direct observation, and he believed instruments and methods of research would be improved and we would eventually secure evidence stronger than the straightness and length of the Martian Canals; what had to be established was the existence of something artificial, something which could not be accounted for by the operation of natural processes. We had fairly straight lines in the rayed craters of the Moon, but we endeavoured to account for these as they exist in Tycho by ascribing them to natural as distinguished from artificial causes. These were points which he thought should be kept in view. There were others, and if the President approved of it, he would at some future meeting read a note on the other side of the question. Meanwhile he would ask them all to join in a hearty vote of thanks to Mr. Banerjee.

A hearty vote of thanks was then offered to Mr. Banerjee for his interesting paper.

The Chairman then asked Dr. Harrison to read some notes made by Mr. Tomkins on Craterlets, and show some photographs of the same on the screen.

The Chairman.—Would members make any observations on this paper and put any questions ? It is suggested that the best information to be gained on Craterlets can be got by having reference to as many photographs as you can get of them. There are also many books on this subject in the Library which may be accepted as a safe authority. A suggestion of Mr. Tomkins to get a proper knowledge of Craterlets is to get the photographs and then measure the distance on the screen.

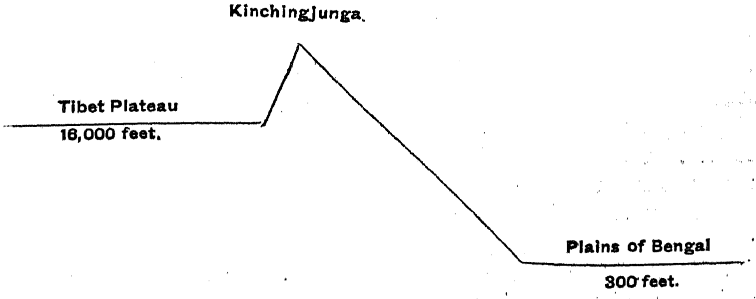
The Chairman then asked the members to accord their hearty thanks to Mr. Tomkins for his very interesting paper, which was done.

The meeting was then adjourned to the 30th April 1912.

Additional Note on the Measurement of Lunar Mountains.

By S. C. Ghosh.

In connection with the paper read at the Society's meeting on the 27th February 1912, Col. Burrard has observed that as the height is calculated with reference to the surface on which the shadow falls, the height thus calculated would not give us such an accurate idea as it would be if the height could be reduced to some standard level, such as the sea-level on the Earth. Taking the case of Kinchingjunga, Col. Burrard has pointed out that the Sun is always south of it. The shadow of the mountain must therefore always fall to the north—



The values of height obtained for Kinchingjunga will therefore be—

		Feet.
If measured above sea-level	...	28,000
,, ,, from bottom of the Indian Ocean		60,000
,, ,, from the shadow cast by the mountain in Tibet	...	12,000

As pointed out by Col. Burrard there may be considerable difference between measurements, made on Mädler's method, according as the shadow falls on a plateau or on a deep crater. It is therefore necessary to make allowances for the height of the plateau or the depth of the crater, whenever this can be known. I have not read Mädler's original work on the subject, but it seems probable that practical astronomers have found some way out of the difficulty. In any case Mädler's method enables us to measure the height with reference to the surface of the shadow, and the results of his investigations confirm the discovery of Galileo that lunar mountains are comparatively much loftier than the Earth's.

Note on an Investigation suitable for Amateurs regarding Lunar Craterlets.

By H. G. Tomkins.

As members are aware prominent features on the lunar surface are those known by the general term craters. Like many other instances such as the canals on Mars in astronomical nomenclature, the name was given owing to the first impression created by their appearance and is perhaps rather unfortunate as it is certain that even if they are due to volcanic action, that action must have been different from anything we are acquainted with on the Earth. Consequently many selenographers prefer to call these formations walled-plains, ring-plains, etc., which are certainly more appropriate names. Careful examination of the Moon's surface, however, soon reveals the fact that, in addition to these larger formations, there are also other much smaller ones, which do in many respects more resemble volcanoes such as we know them on the Earth. These are known as craterlets and crater cones and strangely enough these small features, though they may

well be a most important aid to the elucidation of lunar history, have been comparatively little studied. It is safe to say that to have brought about the extraordinary surface formations on the Moon, some very vast forces must have been at work, and at the present day although the majority of astronomers consider that these forces must have been nearly allied to what we know as volcanic energy on the Earth, that opinion is by no means universal, and moreover there are few who would venture on an opinion as to how, when or to what extent such a force operated, or whether it was comparatively sudden or extended over long ages of time. Now on the Earth the distribution and positions of the volcanoes has an important bearing on its geological history, and these alone teach us much about the forces which exist to shape the surface of the Earth. Assuming for the sake of argument that the craterlets on the Moon are similar in origin to those on the Earth a classification of them as regards position and distribution could not fail to produce important evidence as to the formation of the portions of the Moon in which they are found. Even supposing, however, we proceed on the hypothesis that nothing is known about these craterlets and that they are not similar to the terrestrial volcanoes, an investigation such as the one proposed would certainly result in information by which it would be possible to build up some sort of idea as to the part they play or have in the past played upon the Moon's surface. It would lead to a possible explanation of the craterlets themselves as well as of the country or near which they are found.

Such an investigation is one eminently suited to amateurs in the Astronomical Society of India. For a first survey at any rate no instrument whatever is required except perhaps an ordinary reading-glass, and the work can be done entirely from photographs. Later on perhaps when the first results have been obtained, further observation with the aid of a telescope may be desirable, but for the present, the material available on lunar photographs such as those taken at Mount Wilson and the Yerkes Obeservatory is ample and will provide quite as extensive a piece of work for our members as they will probably be ready to undertake to begin with. The work has the advantage that it can be done at any spare time either during the day or in the evening, and it can be done comfortably under a fan at a table during the hot weather. The only essentials are perseverance, patience and fair accuracy in classification.

A glance at the slides on the screen will give an idea of what the craterlets are like, their size and some of the

positions in which they are found. The slide of Copernicus shows a large number of the craterlets round the main formation. The region is very fertile in these objects, and we find several instances of craterlets in rows, such as those mentioned in my recent lecture in connection with the bolide theory of the Moon and also a large number of single cones. In the next slide we have the hilly country south of the Moon and here are to be seen many of the craterlets on the walls and heights round the ring plains as well as some on the floors. In this third slide the Mare Serenitatis craterlets are to be seen on its floor and in larger numbers round outside the borders of the Mare.

It will be noticed that hillocks occasionally very closely resemble craterlets and care will have to be taken not to confuse the two.

It will be necessary to classify the craterlets in three ways with reference to their relation to each other, their position on the Moon and their distribution with regard to other formations.

For the first it will be necessary to distinguish between those found singly, those found in groups, and those found in crater rows. They might also be sub-divided according to their number in a group or row. The direction of a crater-row will be best indicated by means of lunar latitude and longitude as given on any of the lunar maps. I would suggest an arrangement of work so as to bring the result of the various zones of latitude together. Similarly it will be necessary to examine the longitudes together. This will bring out any tendency there may be for the craterlets either singly, in groups or as crater rows to frequent particular latitudes or longitudes. Then as to their relation to other formations—I suggest the following grouping :—(1) those on level plains : (2) those on heights : (3) those on the floors of ring plains : (4) those on the walls of ring plains, (*a*) inside, (*b*) outside, (*c*) on the crest : (5) those round the borders of the Maria, (*a*) inside the Mare, (*b*) outside the Mare : (6) those situated in the white rays proper : (7) those situated in white patches not forming part of a ray proper : (8) those in or very near to rills : (9) those crater rows related to any formation such as Copernicus and their direction with reference to it.

I propose these as a guide but of course they are not exhaustive and experience may suggest others as the enquiry proceeds. It will probably be found convenient to draw up sheets with columns in them for the various kinds of information required. This will facilitate the tabulation of the

results. A spare column should of course be kept for abnormal details, etc.

Mrs. Voigt, one of our members, has already volunteered to take up this enquiry and the work is well suited to lady members. I hope others will also come forward and a start will be made. If so, it would help matters probably to divide up the classification or to collaborate. I have a certain number of photographs on which a start can be made; there are also some in the library as well as maps of the Moon and others would very easily be obtained.

Habitability of the Planets.

BY U. L. BANERJEE.

Mars.

Now let us consider how far Mars is fit for habitation. This planet travels round the Sun in 687 days and its average distance is 141½ million miles against 92,900,000 miles of the Earth. Its orbit is of considerable eccentricity ; the centre of its orbit being not less than 13,000,000 miles from the Sun. At favourable oppositions it comes within about 35½ million miles from us, and it then shines as a red star of more than twice the brightness of Sirius. The globe of Mars has a mean diameter of 4,230 miles and rotates in a period of 24 h. 37 m. 23 s. on an axis inclined 24° 50′ (according to some 23° 56′) to the plane of its orbit. The substance of Mars has an average density rather less than ¾ of the Earth, or very nearly 4 times that of water. Thus its force of gravity is much less than the gravity on the Earth, inasmuch as that a pound weight on the Earth's surface would weigh only 6 ozs. 3 dwts. on the surface of Mars. Its surface is less than that of the Earth in the proportion of about 25 : 64, or, in other words, the Earth's surface is about 2½ times that of Mars. When Mars is at its mean distance from the Sun, it receives light and heat about 2¼ times less than ours.

The inclination of its axis like our Earth gives it seasons not much different in character than that on the Earth except that the length of each season is nearly double of ours. The Martial axis is situated such that it summers in the northern hemisphere when its distance from the Sun is the greatest. The same thing occurs on the Earth and the Sun is 1,500,000

miles nearer to us in winter than in summer. In the case of Mars the effects are very striking, as it gets half as much light and heat again in perihelion as in aphelion. Thus summer in its northern hemisphere is much cooler, and its winter much warmer, and the contrast between these two seasons is not so striking as on the Earth.

The general surface is reddish in colour, but $\frac{3}{8}$ of it is covered by vivid green tracts, in the main permanent, though subject to minor variations by seasonal changes. These tracts were regarded as seas and oceans. The reddish tracts are regarded as great deserts. They are traversed by long narrow lines. They are thought to be canals, which take their origin from these oceans and could be traced across the continents for considerable distances. They form as it were a kind of net-work connecting different seas and sometimes reaching thousands of miles. They sometimes run in parallel doubled lines for considerable distances, a remarkable feature, nothing like which can be seen on the Earth. There are two white caps at the Poles, which increase until they reach a diameter of 45° to 50°. As summer advances these white tracts shrink in size and assume an area 4° to 5° in diameter and are surrounded by greenish tracts resembling the other greenish tracts and trees on its surface. These polar caps are regarded as snowy polar regions like our Earth which diminish in size by the melting of snow as the summer advances. The simultaneous development of straight greenish lines, connecting their green patches with other green tracts on its surface, led astronomers like Schiaparelli and Lowell to believe that these greenish lines are nothing but water-courses drawing the water from the Poles towards equatorial regions and on both sides of which vegetation abounds.

Besides these canals and the polar caps there are many other parts of the surface of Mars which alter their outlines from time to time. Change of colour, sometimes green, blue, sometimes brown and violet, are often observed on parts of the planet with the change of seasons, from which it is concluded that this is due to growth of vegetation around the watery regions.

The atmosphere of Mars is usually very transparent, although clouds or mists occasionally appear and cause obstructions to our view of the surface. The spectroscopic observations show that the atmosphere is very thin. The mass of Mars is so much smaller than that of the Earth that the force of gravity at the surface of the planet is too weak to retain an atmosphere of anything like the density of our own.

The above are the principal broad facts regarding the physical conditions of the planet. Now let us consider whether it is possible for life like ours to be existing under these conditions. Presence of water, atmosphere and seasonable solar heat, with solid crust of the globe consisting of elements of the Earth, are the chief factors for the existence of such life. Although dark patches on the surface are regarded to be seas or oceans, it is generally believed by astronomers that the body of water on its surface is not so plentiful as on the Earth. In summer seasons the dark patches abound, showing that at other seasons either the water dries up or its volume diminishes to such an extent that it is scarcely visible to the telescopic observer. If it is to be believed that waters completely dry up before the summer, it becomes a perplexing problem, how the water from the Polar regions travel to the equatorial regions by the numerous canals. Force of gravity is out of the question, as there are no high mountains on the Polar regions to allow the water to gravitate downwards towards the Equator.

It can perhaps be conceived that shallow water always exists in the canals and seas setting up a perpetual current between Polar and Equatorial seas (owing to differences of temperature in Equatorial and Tropical regions)—currents like those which exist in the Atlantic and Pacific Oceans of our globe. As either one or the other hemisphere always enjoys the summer season, the current flows with more or less regularity without making any part of the globe completely waterless.

Atmosphere there is although too attenuated to support a being possessing a respiratory organ like ours. But when upon the Earth there are animals who can live on the summits of highest mountains breathing the "thin atmosphere," the attenuated atmosphere does not seem to be a stumbling-block to the existence of life.

Next question is temperature. Astronomers like Professor Lowell and Poynting have calculated the average temperature between 36° to 48° F. As there are several places on our own globe having average temperature much lower, where myriads of animals of different types abound, it can hardly be believed that our ruddy globe with an average atmosphere of Southern England will be devoid of beings; but what these beings are like, what their physical constitution is, whether they are superior or inferior in the order of creation, there are no means at our disposal to know. The questions are left to posterity to solve, if they could ever be solved at all.

Jupiter.

Let us next pass to the giant Planet Jupiter, which is the noblest of all planets wending its majestic course with 4 large and 4 small satellites in an elliptic orbit around the Sun at a mean distance of 483,000,000 miles, which is 5·2 times the distance of the Earth from the Sun. Its greatest distance from the Sun is 5·45, while the least distance is 4·95 times the Earth's distance. Its mean diameter is 87,000 miles, *i.e.*, about 11 times that of the Earth the equatorial diameter being 89,600 miles, while the polar one is 84,400 miles. Its mass is 316, its volume about 1,300 times that of the Earth. Gravity on its surface is about $2\frac{1}{2}$ times as great as on our Earth. The light and heat which it receives from the Sun is about $\frac{1}{25}$ of our supply. Its density is only $\frac{1}{4}$ that of the Earth, *i.e.*, a little greater than that of water. It rotates round its axis in rather less than 9 h. 55 m., so that the length of the Jupiter day is much less than the terrestrial day. The axis is almost perpendicular to the plane of its orbit, the deviation being only 3°, so that there are no appreciable seasonal changes as on our Earth. The period of its revolution round the Sun is about 12 of our year or $4,332\frac{1}{2}$ of our days. Its surface is marked by belts of red and purple and white moving almost parallel to its equator. They form a sort of concentric belts dividing the surface in so many zones. The planet has got 4 large and 4 small satellites, the 5 inner ones revolving round it in about $\frac{1}{2}$, 2, 4, 7 and 17 days, at a distance of 112,500, 261,000, 415,000, 664,000 and 1,167,000 miles from it.

Its habitability depends upon the presence of normal average temperature, atmosphere and water. The intensity of the Sun's heat on the planet is only a mere fraction, less than 25th part of what we receive on the Earth, but as the inclination of the axis is only 3° the Sun passes every day almost perpendicularly overhead at the equator. The maximum heat is thus poured on the equatorial region. As the time of rotation is only 9 h. 55 m. the heat which its surface absorbs in the day time may not completely radiate at night as the atmosphere envelopes store the radiated heat for some time, and the heat may gradually accumulate making the average temperature much higher than it would otherwise have been the case. At the poles the Sun seems to glide along the horizon rising in the east, passing towards the south and then setting in the west. In intermediate latitudes the Sun passes to a southernly elevation, greater or less according as the region is nearer or further from the equator. Thus the temperature varies from its maximum at the equator to its minimum at the poles, giving all shades of climatic conditions to intermediate regions.

Next let us see what evidence there is of the existence of an atmospheric envelope to protect these dark rays radiating into the space. Careful observations of the markings on its surface show that belts running parallel to the equator dividing the surface in so many zones, continually change in shape and size. Their continuity is disturbed by formations like circular spots which completely fill up after a time. Their appearance is like that of so many vortices formed under the influence of storms in our terrestrial atmosphere. Those atmospheric storms of the Earth are the effects of the solar heat. The heat rays striking on the surface warm the air in contact therewith. The heated air becomes lighter and rises, while air from a colder region rushes in to fill up the gap causing thereby a breeze or a wind. Under exceptional circumstances these develop in cyclones and hurricanes. The way in which the surface markings change their shape shows that the air in the equatorial regions is replaced by colder air of the polar regions by a sort of wind corresponding to the trade wind on our Earth, and it is not unreasonable to believe that this change of shapes of the markings is partly due to the disturbance in the atmosphere on the globe. The changes in the surface markings are, however, of exceptionally gigantic nature, so the astronomers do not solely attribute them to atmospheric disturbances. They are of opinion that the planet still retains a portion of its primitive internal heat, and as the Sun is disturbed by violent tempests consequent on its intense internal heat, so in a lesser degree the same phenomenon appear on Jupiter. But what the necessity of that heat is and whether it is apt to make the globe uninhabitable there is not much evidence. Absence of self-luminosity of the globe as proved by the completely dark shadows of satellites thrown on its surface while passing between the Sun and the planet, and complete disappearance of the satellites when they pass through the planet's shadow during the eclipse periods, shows that the internal heat is not like that of the Sun making it unsuitable for habitation.

Astronomers also believe in the existence of aqueous vapour in its atmosphere, and they think that the dark belts are nothing but cloud belts. Their existence could not have been discovered on the edge of the planet's disc by some irregularity in the level—as the cloud must have projected slightly beyond the real outline of the planet. It might be that the atmosphere depth is not large enough to be susceptible of measurement at such long distances and the low height at which the clouds ordinarily suspend on the atmosphere escape detection by telescopes entirely. But whether these clouds condense into

water and whether there is sufficient water on its surface, we have no direct evidence as on Mars.

Taking all these facts into consideration one is led to think that the planet is not a barren globe like our Moon. If it is not inhabited at present, it has, in the distant future, the prospect of a glorious career, as the residence of organic life.

Extracts from Publications.

Dr. Stromgren, of Copenhagen, according to the *Athenæum*, has computed an orbit for the minor planet Hector, taking account of the perturbations produced by Jupiter and Saturn. There are, of course, several hundreds of these small bodies whose orbits are known ; but Hector is one of four which are distinguished for a particular reason. Most of the orbits lie between those of Mars and Jupiter, but in 1898, a planet, since named Eros, was found whose orbit interlaced that of Mars, and in 1906 another was discovered whose peculiarity lay in the opposite direction for it went at times well outside the orbit of Jupiter. Since then others of the same type have been discovered ; so there are now four minor planets, called respectively by the names of Homeric heroes—Achilles, Hector, Patroclus and Nestor.

[*English Mechanic.*

Here is an interesting experiment and an absolute proof of the Moon's rotation. Obtain a light spherical object, such as a boy's football, and paint half of it white. In the centre of the painted hemisphere fix a string about 4 feet long. Raise the arm above the head and swing the ball around at the 4 feet radius at a fairly good speed. The ball now assumes the conditions of the Moon's revolution ; it continually presents the painted side towards the hand. Now without a sudden jerk, release the string, the ball will then fly off at a tangent, and will be observed rotating on its own axis, as it rushes through the air. If it was not rotating when revolving, whence did it get this new motion from ? This simple experiment could be elaborated with ease and a little skill, and would quite crush the opposite theory.—R. W. Green.

[*English Mechanic.*

In a paper presented to the Berlin Academy of Sciences, F. Kurlbaum describes a determination of the temperature of the Sun, based on observations which he had made in Egypt, near Assuan, in February and March of last year. The brilliancy of the Sun's light was compared with the brilliancy of a black body for the wave-lengths 0·651, 0·588, 0·521 and 0·486 μ with the aid of a spectro-pyrometer consisting of a Holborn-Kurlbaum pyrometer and a spectrum apparatus similar to that which Henning used in 1910. The rays were reflected into the photometer by a plate of magnesia which had a reflecting power of 0·870. The resulting Sun temperature would be 5,730 deg. C. absolute on the Holborn-Day scale or 6,390 deg. C. absolute on the Holborn-Valentiner scale.

[*English Mechanic.*

King Sirius.

When royal Rigel glitters like a gem,
  Where gleams Orion's glory in the sky ;
And Queen Capella like a diadem
  Reigns o'er Auriga with a watchful eye,
When Winter's thraldom rests on vale and hill,
  And skies are clear, and stars shine coldly bright,
Ere most men dream or city's voice is still,
  King Sirius again adorns the night.

[*Popular Astronomy.*

Meteors on Christmas night.—Though few meteors have ever been recorded on the night of December 25, it is certain that some conspicuous showers are visible at that time. The dates December 21 and 22 form a little period of special activity, and some of the radiants visible then are also very active, if not at their best, on Christmas night. I may instance streams directed from—

47°	+43°	166°	+ 4°
47°	+65°	166°	+33°
77°	+33°	177°	+10°
130°	+19°	177°	+47°
134°	+ 8°	194°	+67°
145°	+ 7°	203°	+58°
133°	+48°	220°	+78°
159°	+27°	218°	+36°

and there are many others to be detected by prolonged watching.

December 25 this year was showery, but a north-westerly wind cleared away the clouds in the evening, and the stars

shone for some hours with a splendour rarely if ever surpassed in this climate. Meteors were interesting, if not specially abundant.

[*The Observatory.*

Thunderbolts.—The term thunderbolt is generally applied both to the rare phenomenon of ball lightning and to meteoric stones. In the latter case its only meaning is that their luminous path resembles lightning or that they cause great atmospheric disturbance. Here the term is applied only to ball lightning. The singularity of ball lightning consists in the complete isolation of a gaseous sphere having no envelope, yet within which there is energy stored by previous electrical action, which, in the end, is liberated with explosive violence.

From the few records of its appearance, these facts may be considered as established. It is observed as a luminous blue ball occurring after very intense lightning flashes, either falling slowly from clouds, or moving horizontally some feet above the Earth's surface. It is more frequently seen at sea than on land. It appears to move under the action of gravitation on a mass somewhat denser than air, or horizontally in a feeble air current or an electric field of force. The final features are significant. The ball ceases to exist, and an explosion wave travels outwards from the locus it occupied. In all cases a strong smell of ozone follows its disappearance. It is clear there can be nothing present in it but the gases of the atmosphere.

All records agree that a thunderbolt is somewhat heavier than air, and the following facts indicate that thunderbolts consist mostly of ozone in active recombination : (1) ozone is stated to be observed on their dissipation ; (2) ozone is the only gas denser than air produced under electric stress in air, as distinct from streaming spark discharge ; (3) on approaching the Earth thunderbolts are frequently deflected and travel horizontally as if repelled. The Earth's surface and ozone are both negatively charged in general ; (4) the energy liberated on the transition of ozone to oxygen in the volume of the fire-ball is sufficient to account for the explosive violence of its burst ; (5) the blue colour usually observed is associated with the sparkless electrical discharge in air which produces ozone. It has been observed that when oxygen and hydrogen combine explosively in the presence of nitrogen, the explosion flame is yellow. Hence the suggestion that the principal constituent of thunderbolts is an aggregation of ozone and partially dissociated oxygen.

[*English Mechanic.*

Memoranda for Observers.

Standard Time of India is adopted in these Memoranda.

For the month of May 1912.

Sidereal time at 8 p.m.

	H.	M.	S.
May 1st	10	36	35
,, *8th*	11	4	11
,, *15th*	11	31	47
,, *22nd*	11	59	23
,, *29th*	12	26	59

From this table the constellations visible during the evenings of May can be ascertained by a reference to their position as given in the Star Chart.

Phases of the Moon.

	H.	M.	
May 9th Last Quarter	3	26	p.m.
,, *17th* New Moon	3	44	a.m.
,, *23rd* First Quarter	7	41	p.m.
,, *31st* Full Moon	5	0	a.m.

Meteors.

Date.	Radiant. R. A.	Radiant. Dec.	Character.
May 1st—6th	338°	—2°	Swift; streaks.
,, 11th—28th	331°	+27°	Slow; small.
May—June	235°	+ 9°	Rather slow.
May—June	280°	+32°	Swift.
May—July	252°	—21°	Slow; trains.

Planets.

Venus—Is a morning star. The position of this planet on the 15th May at 8 p.m. will be R. A. 2 h. 33 m. 40 s. Dec.

13° 48′ 38″ N. The time of its rising will be 4 h. 12 m. a.m. on the 16th May.

Saturn—Invisible. It rises after sunrise and sets before sunset on the 15th of May.

Mars.—The position of this planet on the 15th of May at 8 p.m. will be R. A. 7 h. 38 m. 32 s. Dec. 23° 6′ 40″ N. The time of its setting will be 10 h. 26 m. p.m.

Jupiter.—The position of this planet on the 15th May at 8 p.m. will be R. A. 16 h. 45 m. 1 s. Dec. 21° 31′ 8″ S. The time of its rise will be 7 h. 25 m. p.m.

Notices of the Society.

Election of Members.

The attention of members is invited to Bye-Law No. 14, regulating the election of persons who desire to join the Society. It is hoped that those who are already members will induce others to join. Forms of application can be had from the Secretary, Mr. P. N. Mukherji.

Change of Addresses.

It is particularly requested that when members change their addresses, they will kindly notify the new address to the Secretary. The omission to do this is likely to cause the loss of the Journals and other communications.

Telegraphic Address.

The address of the Society has been registered at the Telegraph Office, Calcutta. Telegrams should be addressed "Astronomy, Calcutta."

The Library.

A subscription list exists and several members in Calcutta have subscribed and enabled the Council to make a beginning with the Library. Other members outside Calcutta, however, have not, except in one or two cases, yet come forward,

and as the Library will be one of the most important adjuncts of the Society, and will be available to members both in and out of Calcutta, those who have not yet done so are invited to help the Society in making progress with this important branch of the work. Suggestions as to useful books for the Library will also be welcomed by the Librarian.

A number of books have already been received and can be borrowed by members in accordance with the Bye-Laws.

The books available can be ascertained from the Assistant Librarian and a catalogue will be issued shortly. The reading room of the Society in the Imperial Secretariat is now opened for the use of members daily from 5 to 7 p.m. except on Wednesdays and holidays and from 3 to 5 p.m. on Saturdays unless that day is a holiday.

The Journal.

The following charges have been fixed for back numbers of the JOURNAL :—

For members.—Per copy 12 annas ; per volume Rs. 5.

The Star Chart.—As. 12 a copy.

For non-members.—Rs. 1-8 per copy.

The Star Chart.—Rs. 2 a copy.

Subscriptions.

Subscriptions for the current session fell due on 1st October 1911. Those who have not paid in their subscriptions are requested to remit them to the Treasurer at their convenience.

Papers for Meetings.

It is requested that drawings which accompany papers for reproduction in the JOURNAL may be made with Indian ink on white paper. This will insure a clear reproduction.

List of Instruments.

With a view to enable the Council to obtain a knowledge of the instrumental equipment of the members, it is requested that those members who possess any instrument suitable for astronomical work will kindly send details to Director of Instruments of its kind, size and power.

Programme of Work for the Session.

Sub-Committee.—The Council have appointed a Scientific Sub-Committee consisting of the Scientific Secretary and the Directors of Sections. This Sub-Committee will direct the observational and educational work of the Society under the Council, and will consider in detail and take steps to introduce practical work. To begin with, the following are to be considered and taken up :—

(*a*) Instructions and Classes for members who are beginners.

(*b*) Observational Work for those members who will embark on it.

(*c*) Practical Classes for members in Calcutta.

(*d*) Public Lectures in Calcutta.

Members will shortly receive communications from the Sub-Committee regarding these matters.

Public Lectures.

The series of three Public lectures in the Town Hall has been completed. The lecturers were Col. Burrard, R.E., C.S.I., F.R.S., Mr. H. G. Tomkins, C.I.E., F.R.A.S., and Dr. E. P. Harrison, Ph.D., and the subjects were "The Earth as a Planet," "The Moon" and "The Planet Mars." The lectures which were largely attended will be published in a separate volume as a special publication of the Society, and each member will shortly receive a copy free. The price to non-members will be Rs. 3.

Meetings for the Session 1911-12.

Ordinary Meetings.

1912.	1912.
April 30th.	June 25th.
May 28th.	

The meetings will commence at 5 p.m. and, until further notice, will be held in the Imperial Secretariat (Treasury) Buildings.

Addresses of Officers.

Owing to inconvenience which has arisen from addressing the Officers of the Society at their private address, it has been decided to receive communications on the business of the Society in future as follows :—

	To
Money orders or letters containing money or cheques.	U. L. BANERJEE, ESQ., Office of the Accountant-General, Bengal, 3, Koila Ghat Street, CALCUTTA.
All other communications	(*Name*) ....Esq. (*Designation*) ....of the Astronomical Society of India, Imperial Secretariat (Treasury) Buildings, Calcutta.

It is requested that the communications may be addressed accordingly.

Officers and Council.

FOR THE SESSION 1911-12.

(1) *President* . . .	H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.
(2) *Vice-Presidents* . .	(1) COL. S. G. BURRARD, R.E., C.S.I., F.R.S.
	(2) J. EVERSHED, ESQ., F.R.A.S.
	(3) SREE RAJA A. V. JUGGA RAO BAHADUR GARU, F.R.A.S., F.A.I., F.R.M.S., F.A.S. & C.
	(4) H. H. THE MAHARAJA RANA BAHADUR SIR BHAWANI SINGH, K.C.S.I., F.R.A.S.
(3) *Secretary (Scientific)* .	DR. E. P. HARRISON, PH.D.
Do. (Business) .	P. N. MUKHERJI, ESQ., M.A., F.R.E.S., F.S.S.
(4) *Treasurer* . . .	U. L. BANERJEE, ESQ., M.A.
Directors of Sections—	
Lunar Section . .	H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.
Meteor Section . .	P. C. BOSE, ESQ.
Variable Star Section .	LIEUT.-COL. LENOX-CONYNGHAM, R.E., F.R.A.S.
Instrumental Director .	S. WOODHOUSE, ESQ.
Director of Classes . .	B. N. RAKSHIT, ESQ.
Librarian . . .	C. T. LETTON, ESQ.
Editor	J. J. MEIKLE, ESQ.

OTHER MEMBERS OF THE COUNCIL.

J. C. DUTT, ESQ., M.A., B.L.
F. W. HOWSE, ESQ.
A. T. MITRA, ESQ., M.A.
J. C. MITRA, ESQ., M.A., B.L.
C. W. PEAKE, ESQ., M.A.
SARODA CHARAN MITTER, ESQ., M.A., B.L.
W. J. SIMMONS, ESQ.
C. K. SIRCAR, ESQ., C.E., M.S.A., M.S.E.
W. A. LEE, ESQ., F.R. MET. S.
MISS ALICE MCLEOD.

The Journal of the

Astronomical Society of India.

Vol. II.] SESSION 1911-1912. [No. 7.

Report of the Meeting of the Society held on Tuesday, the 30th April 1912.

H. G Tomkins, C.I.E., F.R.A.S., *President*, in the Chair.

W. J. Simmons, for the *Secretary*.

The usual Monthly Meeting of the Astronomical Society of India was held in the Imperial Secretariat Buildings (Ground Floor) on Tuesday, the 30th April 1912.

The Minutes of the previous meeting were read by Mr. Simmons, in the absence of Mr. Mukerjee, and confirmed.

The President then announced the following presents given to the Society, and a vote of thanks was accorded to the donors :—

1. Monthly Notices of the Royal Astronomical Society (Vol. LXXII, No. 4).
2. Journal of the British Astronomical Association (Vol. XXII, No. 5).
3. Revista Di Astronomia Anno VI No. 3.
4. Monthly Weather Review of the Alipore Observatory for December 1911.
5. Anuales de L'Observatoire Royal De Belgique (Tome V. Fasgigule I).

6. Rappert Annuel Sun l'Etat de L'Observatoire de Paris Pour l'Annee 1911.

7. Journal of the Royal Astronomical Society of Canada Vol. V, No. 6.

8. Bengali Journal " Bignan," Vol. I, No. 3.

The President then reminded the members of the fact that the telescope given by Dr. Harrison had come, and would shortly be mounted, and said that members might use it on sending in their applications to the Secretary or himself, stating when, where and for what purpose they were going to use it.

The President also announced that the monthly treatises of the Royal Astronomical Society purchased out of the donation, so kindly given by His Highness the Maharajah of Jhalwar, had arrived and were now in the library and available to members who would like to make use of them.

The election of the following members was then confirmed: Mr. E. Moller, Mr. G. Pierce, Mr. K. S. Dikshit, Mr. C. L. Demetrius, Miss M. C. Feline.

The President then called on those members present who had not done so, to sign the Roll of the Society and he then formally admitted them.

The President then asked Mr. Simmons to read his paper on the " Habitability of Planets and the Apparent Waste in Nature."

Before reading his paper Mr. Simmons expressed the pleasure of himself and the members at seeing their President again in the Chair after his recent accident.

The President, in asking members if they had any observations to make on the paper, said that there were three points which struck him during the reading of Mr. Simmons' paper.

First with reference to the mention of the star Algol. A paper regarding Algol had been given about a year ago by Colonel Lenox-Conyngham showing that the variation of Algol was due to a dark planet revolving round it. Members might like to refer to this paper, which is in one of the early numbers of the Journal.

The second point was in connection with the question of waste. It was necessary to have some definition of waste, and he thought one was going a little too far when he spoke of a planet as waste because it was uninhabited. He was not quite sure whether Mr. Simmons intended to put this forward as a finality, but the idea that a planet would be wasted without life seemed to arise from what was said. He thought that many might disagree with this view, and he himsellf would not care to go so far as to say it was the case. The third point was in the termination of the paper. It is said that the pith

of a letter is found in the post scriptum. He did not mean to say the same of Mr. Simmons' paper, which was full of interest throughout, but it occurred to him that Mr. Simmons had included a very valuable suggestion in the last paragraph of his paper. He referred to the use of analogy in considering scientific matters. He (the President) thought that analogy was a most useful aid in research work. It at any rate serves to prevent people from propounding impossible theories to account for phenomena which they do not understand, and when we are asked to accept these fairy tales, analogy with things which we know is a very useful test. For instance, it was against the idea that meteors came down with such force and of such size on the Moon as to result in formations there over four hundred miles in diameter. We had no experience of this kind of thing, nor was there anything analogous to it that we know of elsewhere.

Analogies are very useful to enable us to reason from those things which we know to those which we do not know and thus to help us to a true explanation of what we wish to investigate. They are of course only an aid to research and should not be pushed too far, but Mr. Simmons gave us a very valuable lesson when he spoke in his paper of applying analogy to matters of the kind he treats of as well as many others.

Mr. Simmons said his views of what constituted "waste" were influenced by Mr. Lowell's remarks as to life being an inevitable phase of planetary evolution, the outcome of a planet cooling down. Mr. Lowell's postulate was that life was Nature's highest product. If this was correct, then if a planet failed to produce life it must be regarded as a case of apparent waste in Nature.

Mr. Simmons agreed with the President in rejecting the meteoritic origin of the Moon, and was himself disposed to agree with those who considered that the Moon had once been part of our Earth, and had broken away from it leaving the gap we know as the Pacific Ocean. He also said that spectrum analysis as applied to stellar observations was based on the method of analogy.

A vote of thanks was accorded to Mr. Simmons for his paper.

The President then asked Mr. Simmons to read a note on a Meteor by Mr. Hart.

The President.—"It is doubtful whether the drawing is the exact colour of the meteor. The meteor is evidently a large one. Mr. Hart does not say whether there was any trail."

Mr. Raman.—"Can we get a spectrum of a meteor photographically?"

President.—I think it would be very difficult to photograph. I don't know if you have tried it, but I exposed seven plates during the meteor showers of November 1898. Though we recorded 52 meteors a minute at one time of the night, I was unable to take any photographs and the plates were blank.

If anything of the kind has been done I think it would be recorded in the Monthly Entries of the Royal Astronomical Society. This will be the best place to look.

The thanks of the members were then accorded to Mr. Hart for his note.

President.—"If I am not imposing on Mr. Simmons, I will ask him to read the paper sent by Mr. A. McInerney on the construction of a universal sun-dial."

I think in regard to this paper we must have Mr. McInerney's figures on the screen by means of a lantern slide as, A. C. B., etc., are Greek to the people present who are too far off to see the drawing. We had a design for a sun-dial some time ago which was very complicated in comparison to the one we have now seen. For the next meeting we will have a lantern slide of it.

A vote of thanks was accorded to Mr. Mc.Inerney for his paper.

President.—I will now ask Mr. Simmons to read the note sent us by our friend Rev. Mitchell on the appearance of the planet Mercury.

The notes were then read.

President.—Would any one like to make any observations regarding these notes ?

Mr. Banerjee.—We know that stars twinkle, but do planets twinkle too ?

Mr. Simmons observed that the phenomenon of twinkling was one which had not been quite cleared up. A Belgian observer, M. Montigny, who had given the subject his attention, found that the approach of rainy weather increased the twinkling of stars. It is more marked when a star is near the horizon (as Mercury always is when observed with the naked eye) but diminished as a star approached the zenith, and cited Sirius as an example. It is more observable from the surface of the ground than it is from mountain-tops. This showed that the depth of atmosphere through which a star is seen affects its twinkling. The Belgian observer also found that the phenomenon was to some extent dependent on the spectroscopic character of the light of a star.

President—Would any one like to ask a question ?

Mr. Simmons has fully answered the question of twinkling, and twinkling in a planet is due to the cause that Mercury is never high up in the heavens.

There is very little doubt that twinkling is due to the atmosphere; it all depends on the state of the sky.

The President then showed some lantern slides on the very interesting subject of craterlets.

He then adjourned the meeting to the 28th May 1912.

The Habitability of the Planets and the Apparent Waste in Nature.

BY W. J. SIMMONS.

It is a recognised principle in science to argue from the known to the unknown. We are familiar in the world around us with the little pitted marks which rain leaves in the soil, and with the footprints which wading birds leave on the mud on the banks of a river, or which ripples leave on a sandy beach. When we discover similar markings in a stratum of rock buried deep down in the Earth's crust, we infer that tens of thousands of years ago rain fell, and wading birds stalked about, and ripples washed and broke on this planet in the old times before man appeared on the scene to till the ground. Furthermore, we may even be able to learn something from the silent testimony of the rocks about the direction from which the wind blew, and the intensity of the storm. We have argued from the known to the unknown; we have reasoned from parallel cases, *i.e.*, we have proceeded by the method of analogy, the method which has also been adopted in anthropology and other sciences.

So, too, when we find that one of the planets has its axis of rotation so adjusted to the plane of its orbit as to secure seasons which in some degree correspond to the seasons we experience on our Earth; when observation satisfies us that the diurnal revolution of the planet concerned gives it the phenomena of day and night; that its poles, alternately at intervals of a few months, put on white caps which suggest those worn by our Earth in its Arctic and Antarctic regions; that it has an atmosphere more or less cloud-laden, that when occasional glimpses can be obtained of its surface, markings are unveiled which bear what we may regard as a rough resemblance to the surface markings of our globe; that where clouds are there must be some fluid whose evaporation under the action of the Sun's heat forms cloud-masses

similar to those which belt our world in its equatorial and trade wind zones: we admit that we have discovered the existence of certain conditions which in the case of our Earth have been favourable to the development of organic life forms. In applying this analogical argument to the case of any of the planets—if I may adopt what J. S. Mill says in the chapter in his Logic devoted to the discussion of the argument from analogy—we must remember that where the resemblances between, say, Mars and our Earth are great, and the ascertained differences are small, and further where our knowledge of the subject is extensive, the argument from analogy may approach in strength very near to a valid induction. If, however, every resemblance proved between Mars and the Earth in any point not known to be immaterial with respect to life constitutes some additional reason for presuming that life-forms as we know them exist in Mars, then it is obvious, *econtra*, that every dissimilarity which can be proved between the two planets furnishes a counter-probability of the same nature, but on the other side. In such a case if animal life does exist in Mars, it must be, and clearly can only be, as an effect produced by an environment, that is by an assemblage of causes, different from those on which life depends on the Earth; or to put it in other words, life in Mars must be a consequence not of that planet's points of agreement, but of its differences from the Earth. In such case, what becomes of the inferences we would draw as to the character and capabilities of living organisms in Mars? If they have been evolved in an environment differing from that obtaining on this Earth it is idle to conjecture in what respects they resemble or differ from the plants and animals around us. The fact is that our knowledge of the environment in any one of the other planets is not sufficiently extensive to justify our carrying the analogical argument very far. When I say this I chiefly have in view the claims made for Martian life-forms possessing a degree of reasoning power; organizing and co-operative capacity; and all else that the term intelligence connotes, not merely equal to, but if anything rather superior to the degree of intelligence exhibited by the animal organisms inhabiting this Earth. The coarse mosses and dwarfed Arctic plants of the frozen marshes of northern Russia; the cacti and the euphorbiaceæ of the Sahara, where the sandy surface reaches a day temperature of 150°F, and is chilled below freezing-point at night, are life-forms, but we do not attribute reasoning power in any degree to them. Now, I think I am correct in saying that it is admitted that the surface of Mars appears to be uniformly level. Mr. Lowell tells us there are no mountains on Mars exceeding 2,000 to 3,000 feet in

height; the planet's characteristics are probably those of a desert region in which the terrible desert conditions of the Sahara prevail.

And this leads me to direct your attention to other observed facts which I submit cannot be ignored if we would deal fairly with the different series of phenomena on which we seek to base our analogical argument. I mean the apparent waste in Nature. When first I set about collecting materials for this paper I was not aware that Prof. Whewell in his "Plurality of Worlds" (1854), and Mr. A. R. Wallace who touches very lightly on the subject in his "Man's Place in the Universe," had anticipated me in recognising the force and value of what I term the argument from apparent waste. The scope of that argument may be realized from a stanza in Tennyson's "In Memoriam." In the powerful verses in which the poet would remind us of Nature's apparent care of type forms, and her reckless waste of individual lives, he says —

> "I considering every where
> Her secret meaning in her deeds,
> And finding that of fifty seeds
> She often brings but one to bear,
> I falter where I firmly trod."

Mr. Wallace says the same thing when he tells us the mind reels under the immensity of, to us, apparently useless life. A commentator of the "In Memoriam" (Alfred Gatty, p. 60) in a footnote says: "The early purple orchis is said to bear 200,000 seeds, and perhaps one only grows to a plant." Mr. Wallace says that of the millions of acorns produced during its life by an oak, every one of which might grow to be a tree, it is probable that only one does actually, after several hundreds of years, produce the one tree which is to replace the parent. He meets the argument which may be based on the circumstance that acorns form food for beasts by recording that this cannot be urged on behalf of the seeds of orchids and the spores of ferns, for millions of these literally go to waste for every one that reproduces the parent form. Grant Allen in his monograph on "Charles Darwin" says (p. 94): "A single red campion produces in a year three thousand seeds; but there are not this year three thousand times as many red campions as there were last summer, nor will there be three thousand times as many more in the succeeding season. The roe of a cod contains sometimes nearly ten millions eggs; but supposing each of these produced a young fish which arrived at maturity, the whole sea would immediately become a solid mass of closely-packed codfish." Wallace in his "Darwinism" records that

a single flesh fly (Musca Carnaria) produces 20,000 larvæ which in five days reach adult life, and that the great Swedish Naturalist, Linnœus, asserted that a dead horse would be devoured by three of these flies as quickly as by a lion. Packard, an authority on Entomology, in his Guide to the Study of Insects (p. 566) says that the eggs of the Katydid, one of the locust family, are about the eighth of an inch in length and that they resemble tiny oval bivalve shells. You may form some opinion of the enormous number of locusts when, citing from the last edition of the Ency. Brit. (Vol. 16, p. 858), I tell you that in one year, 1881, the estimated weight of the locust eggs destroyed in Cyprus exceeded 1,300 tons. This batch included one thousand six hundred millions of egg-cases, each case containing a considerable number of eggs. Yet in 1883 not fewer than five thousand and seventy-six millions of locust eggs are believed to have been deposited in Cyprus. Those of us who have witnessed a flight of locusts here in India must have been impressed by the appalling fecundity of Nature. Remembering that swarms of these insects visiting a district have often accentuated, if they have not caused, famine, and all the misery and death which in India follow in the wake of famine, one cannot overlook the devastation occasioned by cyclones such as that of 1876 which destroyed 30,000 persons in Hatia, 40,000 in Sandwip, and 74,000 in Backergunge, to say nothing of the enormous number of cattle destroyed by these terrific storms. The lemming is a small Scandinavian rodent about five inches long, something in general appearance like a rat with a short tail. It produces two broods annually each consisting of generally five, sometimes three, and occasionally eight young ones. At intervals varying from five to twenty years the cultivated lands of Norway and Sweden are overrun by such huge battalions of lemmings that the simple peasantry of Norway believed they dropped from the clouds, and trekked across country to their original home in the submerged island of Atlantic. Their onward march, which takes place at night, never ceases until they reach the sea, and may last from one to three years. When they reach the ocean they plunge into it, recklessly swimming onwards in the same direction till they perish in the waves.

You will now realize what I mean by the argument from apparent waste in Nature ; but, you may say, all these instances are drawn from organic life—what about inorganic nature ? I would answer your enquiry by turning to our own solar system. It is not claimed, now-a-days at least, that the Sun is inhabited, nor yet the Moon, nor the comets, nor the satellites of other planets, nor the six hundred and seventy

odd asteroids, nor even Mercury. About Venus no definite opinion can be formed as the body of the planet is always swathed in a heavy veil of clouds. We must, therefore, return a Scotch verdict of not proven in the case of Venus. The case of Mars may for the present be regarded as *sub-judice* ; while the most hopeful exponent of the plurality of worlds would in the cases of Jupiter and Saturn claim that they are destined to be inhabited some day, but are not so to-day. Of Uranus and Neptune we do not know enough, but what we do know does not seem to entitle them to rank higher than their two immediate neighbours. Passing now beyond the limits of our solar system, to the background of stars beyond, it is interesting to note that binaries of the Algol type have a special lesson for us in our speculations on the habitability of the stars. Vogel in 1899 showed that the variability of the Demon Star in Perseus, the star in the angle of the easternmost limb of the Greater W. is due to its suffering a partial eclipse at short intervals in consequence of a dark companion star passing before it. Since then a large number of the brighter stars have been spectroscopically examined, one by one, with the surprising result that " one star out of every four or five examined proves to be a spectroscopic binary and the proportion seems to grow steadily larger." What, it may be said, has all this to do with the habitability of stars ? My answer will be in the words of Prof. Arthur R. Hinks, who, writing his little Manual of Astronomy as lately as June 1911—not a year ago—says : " The discovery of so many spectroscopic binaries disturbs the idea, drawn from our own solar system, that the function of a star is to nourish with heat and light a family of planets. The terrible problem of the motion of a planet round a pair of suns has not yet been solved, but it seems quite unlikely that such a planet could pursue an equable way conducive to the development of life upon its surface." (P. 180.)

In casting around for analogies we must not restrict our choice to those that suit us—,*e.g.*, to the size of a planet, its diurnal and annual revolutions, the inclination of its axis to the plane of its orbit, and so forth. There are places on our own Earth which do not conduce to the maintenance of living organisms. Excepting Mars as a case reserved, our Earth seems after all to be the only body revolving round the Sun fit for the habitation of living forms as we know them. However, unwilling to do so, we must so far as their capability of sustaining life is concerned, relegate the rest of the bodies which derive their heat and light from our Sun to the category of what so far as indigenous life is concerned, we may term apparent waste in Nature. And when we leave

our solar system behind us, and speed across the lonely and ice-cold Zaarahs of space to the remote background of the fixed stars, we are forced to acknowledge that recent spectroscopic research does not conduce to the belief that inhabited planets like our world circle round each of the brighter stars. The argument from analogy seems to point quite the other way, though obviously in the case of those numerous stars which neither the telescope nor the spectroscope can resolve into doubles, it must be admitted that the scope for both speculation and enquiry is considerably widened. Obviously if the claim set up for the plurality of worlds is limited to the planetary orbs being the habitat of vegetable organisms only, or if it was confined to vegetable organisms and the lower types of animal life represented on our Earth by the Protozoa and the Annulosa, it might be conceded that such types of life do probably exist on Mars on the one side of us, and Venus on the other. But, as I understand it, the claim advanced is far more extensive. The social instincts of man influence him to people the planets with beings like himself; and it is correctly recognized that to support such a claim we must find in Mars, or in Venus, indicia which with reason can be claimed to be artificial, in a word which are "evidences of intelligent engineering upon a gigantic scale." Mr. Percival Lowell claims to have found such indicia in Mars, and any claim advanced by him in this direction is entitled to respect. He has practically devoted his life and his great abilities and special opportunities to the problem of solving the question —is Mars inhabited? His studies have been prosecuted with the help of skilled assistants, in an observatory admirably equipped with the necessary instruments, and situated in an atmosphere so suitable to stellar observations that stars which cannot be detected with a given power elsewhere, are plainly visible with the same power at Flagstaff Observatory in Arizona. Moreover, while the proximity of the Moon to our Earth has satisfied competent authorities that no life exists on our satellite, Mars is so situated with regard to the Earth that it is the one planet on which, if on any, we may hope to find evidences of intelligent life. And yet, closing his discussion of Professor Lowell's claims on behalf of Mars, Mr. Arthur Hinks observes: "We can only say that there is as yet no proof at all of the actual existence of intelligent life on any world but ours." (P. 87.)

A few words more and I have done. We have had more than one note lately on the question of the habitability of other planets and in all of these recourse has been had to the use of the analogical argument. We have seen that that argument at its best only establishes a probability more or less

strong, but that it does not amount to a positive and valid induction. What object then is served by these enquiries, seeing that our Society exists for the very practical purpose of encouraging independent research and observation ? Let me answer that question in John Stuart Mill's own words: "The cases in which analogical evidence affords in itself any very high degree of probability are only those in which the resemblance is very close and extensive; but there is no analogy, however faint, which may not be of the utmost value in suggesting experiments, or observations, that may lead to more positive conclusions." (Mill's System of Logic : p. 368).

Note on two Meteors.

By P. C. Bose.

On the evenings of 10th and 11th March I saw two meteors that seemed to radiate from Puppis. They were very slow, not very bright and left very thin trails. They took about 4″ to pass. In appearance they resembled cheap rockets such as are seen on Dewali nights. I shall be pleased to receive communications from members who have made observations about these or any other meteors.

A Note on a Meteor.

By H. Hart.

When sitting out in my garden on Saturday evening, 16th inst. at 7-42 I was conscious of a sudden brightness in the overhead sky; and looking up I saw a most brilliant meteor travelling north-west from the zenith between Mars and β Tomri (Nash). It dropped with great swiftness between the Pleiades and Perseus and disappeared in Triangulum. I reckon it took about four seconds to travel from between Mars and Nash to Triangulum.

I have never seen a meteor of similar size and brightness. It appeared to be about one-fourth the size of the Moon—a well defined orb, having three colours—red, yellow and green brilliantly distinct. The tail was insignificant, being barely a degree in length.

Notes on the recent Appearance of Mercury.

BY THE REV. J. MITCHELL.

25th March 1912—Mercury invisible to the naked eye, but easily visible in a field glass X4. Sky clear.

27th March 1912—Mercury visible to the naked eye about one hour after sunset. Twinkles like a fixed star. Estimate magnitude about ·7. Clear sky.

29th March 1912—Mercury easily visible to the naked eye. Twinkles.

30th March 1912—Mercury very easily visible to the naked eye from one hour to 1½ hours after sunset. Twinkles quite perceptibly. Clear sky. No doubt as to its being Mercury. Corresponds exactly to Ephemeris given in E. M. Compared its position also with Hamal. β and Y aries.

31st March 1912—Saw Mercury 25 minutes after sunset. Sky perfectly clear. Mercury twinkles. Visible nearly 1 hour. Magnitude about 1. Nearly equal to Saturn.

1st April 1912—Cloudy, but Mercury again visible low down near horizon. Still visible to the naked eye.

3rd April 1912—Sky clear. Mercury very faintly visible to the naked eye; easy in glasses X4, getting fainter.

4th April 1912—Could find no trace of the planet to-night. Looked for over ½ hour.

N.B.—Why does Mercury alone of all the planets twinkle.

A Home-made Sun-dial.

BY A. McINERNEY.

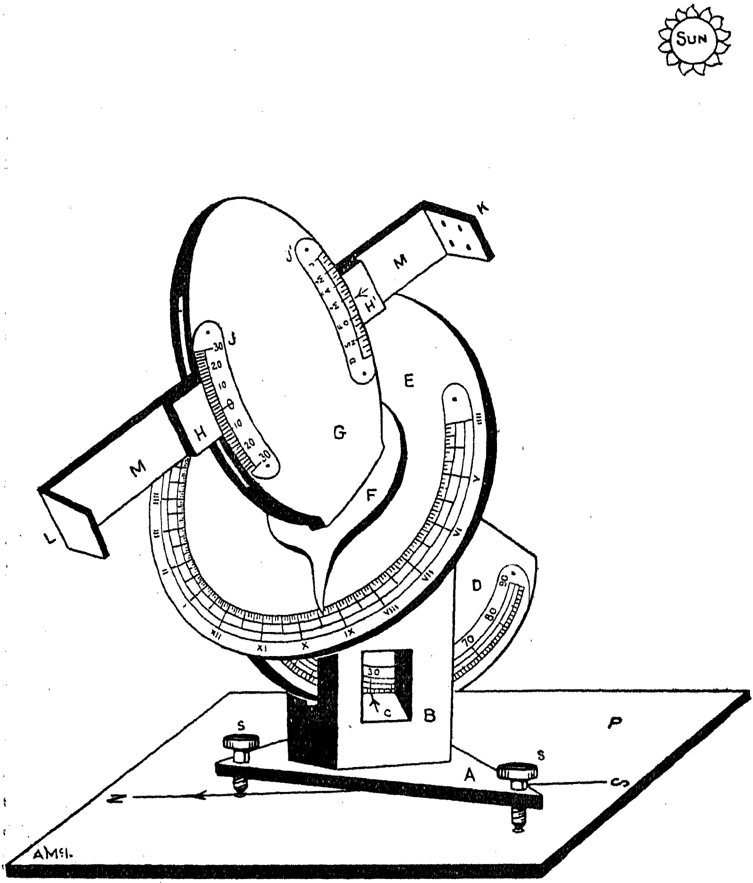
This sun-dial can be made by anyone with a little wood, cardboard and brains; it will be found universal for all places and as accurate as the ingenuity of the maker chooses to make it.

To a triangular board A (about 6 inches sides) is securely fastened the slotted stand B, the slot being exactly opposite one of the points of the triangle ; on this slotted stand B all the parts above it, *viz.*, DEGM, swing and an opening is provided at C for reading the latitude. The quadrant D is fastened at right angles to the underside of the large disc E and swings with it for adjustment to latitude. The larger the disc E the better, but a 10″ inch old gramophone disc is a convenient size. On this Time Disc E the small disc F (with a time finger) is fastened so that it can revolve round the centre point of disc E. Rigidly fastened to F and at right angles to it is the Declination, circular plane G with graduated arcs at J for degrees and J′ for 21st of each month, the former arc for accurate adjustment and the latter for approximation only. About the centre of the Declination plane G the arm M M can move up and down through about 60° of arc and the arm is furnished with an index at H. and H′, for adjustment with J or J′; at the extremities of the arm two small square plates K and L are securely fastened truly parallel with one another and at right angles to the arm. The projection K is perforated by four tiny holes (forming the corners of a square) and the opposite piece L is marked with two lines perpendicular to each other and quartering the plate. A small spirit level procurable at any ironmonger's completes the sun-dial.

To use the Sun-dial.—On any fixed fairly even and level surface P (such as a pillar, flat roof, etc.) mark the Meridian line. This is easily done by making a series of concentric circles, fixing a pin or style in the centre and marking the shadows of equal length cast in the forenoon and afternoon of any particular day and then bisecting the angle formed by these two shadows. This gives the true Polar North and South ; having obtained this line on the fixed surface, take any convenient point on it and draw an equilateral triangle with this point as an apex ; the sides of the triangle to be exactly equal to the distance between the points of the adjusting screws SSS of the sun-dial, and the Meridian line must bisect one side of the triangle ; at each point of the triangle make a small shallow hole. Now take your sun-dial, revolve the quadrant D till index at C points to the observer's latitude ; next set the index at H′ to the date at J′ or more accurately H to the Sun's declination (from a Whittaker or Nautical Almanac) at J. Next take the instrument into sunlight to your fixed surface P and place the three screw points into the three holes already prepared on the plane P, so that the quadrant disc D lies over the Meridian line. Now revolve the small time disc F (with its superstructure G) till LK points to the Sun, and when the four tiny dots of light through K are accurately divided up from each other by the lines on

L read off the time indicated by the finger on F, which will give the true solar time. See that the board A is quite level first by means of the small spirit level.

This instrument as described above will read accurately to minutes, neglecting the equation of time, and the writer has made one with verniers and tangent screws to read accurately to ten seconds allowing for the equation of time and indicating solar, mean and standard times simultaneously.



A The Base.	E Time Disc.	JJ Decln. Arcs.
SSS Levelling Screws.	F Time Index.	K Perforated Elbow.
B Slotted Stand.	G Declination Disc	L Blank Elbow.
C Latitude Index.	H Decln. Index. (degrees).	MM Decln. Arm.
D Latitude Quadrant.	H ditto (months.)	P Table or Surface.

Extracts from Publications.

OUR OLD EARTH.

Some facts and misconceptions.—From many points of view, remarks the *Leeds Mercury*, there is much of which we are ignorant concerning this old world of ours. Thus, we are not quite certain even as regards its exact shape, and there are many what would appear to be elementary facts regarding which our knowledge is either very limited or at any rate not complete.

Thus the Earth does not spin steadily round a fixed axis, the ends of which are represented by the poles. It has long been known that the magnetic poles of the Earth slowly change their position, but the same is true of the geographical poles. Not only is this the case, but it has been demonstrated that the apparently sedate old Earth is not nearly so steady as she appears, but that she actually executes a kind of waltz, shifting her axis from time to time.

It is true these motions are very slight. The poles never shift above thirty feet from their mean position in consequence of this irregular motion. It has been suggested that the reason for the movements is the changes which take place in the polar ice-caps, according to the severity of the season, a greater or less amount of ice accumulates at the poles and this has the effect of changing the way of the Earth at these portions ; or to speak strictly, of altering the centre of gravity of the Earth.

Then we are taught at school that the shape of the Earth is an oblate spheroid, and this shape is illustrated by stating that it is much the same as an orange, the Earth being flattened top and bottom at the two poles. By accurate measurement it appears that the diameter of the Earth through the poles is twenty-seven miles less than the diameter of the equator. It is believed, however, that the popular statement is not the entire truth ; that is, the flattening is not the same at each pole. Recent polar discoveries tend to show that the flattening is greater at the North Pole than at the South.

Sea not level.—Another peculiar discovery is that the equator itself is not a true circle. A good deal of investigation has still to be made in this subject, but sufficient has been established to show that the shape of the Earth is not nearly so simple as was imagined some years ago.

We frequently speak of "sea level" as the basis for measurements, fondly imagining that the sea itself is at

the same level throughout the globe. Investigations have shown that the sea is by no means level; of course, no reference is intended here to the factor of tides and change of this sort.

It has been established now that there are actually mountain ranges of the sea, so that the level varies in different portions of the world. Thus, while most persons would imagine that the Pacific Ocean and the Atlantic Ocean must necessarily stand at the same level, the fact is that along the coast of South America, the Pacific Ocean is actually something like 2,000 feet higher than is the water of the Atlantic touching the land straight opposite.

Again, in the Bay of Bengal the water is heaped to a height of 300 feet above that of the water in the Indian Ocean. The explanation of this heaping-up of the waters is the attraction exerted by the vast land mountains in the neighbourhood. Thus, the American Andes exert an attraction which tends to heap up the South Pacific, while the Himalayas permanently maintain great mountain masses of water in the Bay of Bengal.

Some years ago it was imagined that the atmosphere extended only for somewhat about thirty miles above the mean level of the Earth. At present it is believed that 150 miles is a nearer estimate. All the same, we are quite ignorant as to the real extent of our atmosphere. We are in the same position as crawling creatures would be at the bottom of a deep sea, creatures which could not rise to the surface and had to make more or less shrewd guesses as to the height of the fluid which pressed upon them.

Depth of the atmosphere.—The principal method of estimating the depth of the atmosphere is based upon the meteors which visit us. These are pieces of astral matter sent flying through space, but which come within the Earth's attraction and so are drawn to its surface. Owing to the enormous pace at which these pieces of matter travel, they become heated to incandescence as soon as they meet the friction of our atmosphere, and so accurate observations give us some idea of the distances which they travel while in a luminous condition.

Possibly the greatest of all problems concerning this world of ours is what exists beneath the Earth's crust. It is really surprising how little we know of the interior of the Earth. Thus we speak about the crust, although this is somewhat of a misnomer. We know no more about the interior of the Earth than we should know of the interior of an orange from a mere inspection of its skin.

In fact, those small depressions on the skin of an orange are deeper in proportion to its bulk than are the deepest holes in the Earth's surface compared to the bulk of the Earth. Thus, we cannot claim to have done more than merely scratch the surface of the Earth so far, and so we have to guess more or less shrewdly at what is beneath.

Internal Heat.—So far as regards the surface of the Earth, we know that the deeper a pit descends the higher becomes the temperature. This is the case in every part of the world, and, generally speaking, for every sixty feet below the surface the temperature goes up 1 degree F.

If this increase goes on with the depth, it follows that at the centre of the Earth there must be a heat terrifically beyond anything with which we are directly acquainted. At a depth of thirty miles the heat would be such as to fuse any rocks at atmospheric pressure. This is why the earlier geologists imagined that we lived on a fiery fluid globe whose crust only had cooled, and that volcanoes were simply taps letting out some of the subterranean fires.

It is tolerably well established now that there is no foundation for such a belief, and that whatever may exist at the centre of the Earth it is not a mass of fire. This fire theory was the earliest of our beliefs concerning the Earth, and strangely enough, in most religions the lower world was supposed to be of fire. Pluto, Proserpine and Vulcan held their sway in the lower world in a region of fire, and it was there where Vulcan forged the thunder bolts of the mighty Jove.

It is comparatively easy to weigh the Earth as a whole, and this has been done within the limits of reasonable accuracy with the result that we know that the Earth is about five and a half times heavier than it would be were it composed of pure water. Also experiments have shown that the weight of the portion of the Earth which we can handle is something less than three times as heavy as water. Hence the density of the whole Earth is roughly twice as great as that of the rocks at the surface. In other words, the inside of the Earth is much heavier than the outside.

Beliefs concerning the Earth.—Some have believed that the earth is built up of layers after the fashion of an onion. Others that between the centre of the crust there was an ocean of fused material. All the best authorities, however, long have discarded the notion that there is a great central fluid mass.

The late Lord Kelvin showed that the attraction of the Sun and Moon, which produces our tides, would have caused the Earth to burst were the interior fluid, unless the Earth's crust were 2,500 miles thick. He showed that the tidal force

is so enormous that if the crust of the Earth were continuous still it would yield as much as if it were india-rubber to the Sun's and Moon's attraction.

The whole subject is still in a somewhat mixed-up condition, but the latest belief is that the Earth's central mass is metallic, and that it is as hard and solid as so much steel. At our earthquake-recording observatories, tremors have frequently been recorded which have come from Japan right through the centre of the Earth, and it is known that such a tremor could not possibly pass unless the earth had a rigidity approaching that of steel. We are perfectly ignorant, however, as to what the metal is which forms the bulk of our Earth. Very probably it is a combination of metals, but it is impossible here even to hazard an opinion, or to do anything else than to record our complete ignorance of the matter.

[*English Mechanic.*

At the monthly meeting of the Royal Meteorological Society held on the evening of Wednesday, March 20th, Prof. Otto Patterson delivered a lecture on "The Connection between Hydrographical and Meteorological Phenomena." He began by saying that the mediæval age was characterized by frequent violent climatic changes, which seem to have culminated in the 13th and 14th centuries, when hot summers accompanied by draughts (which nearly dried up the rivers of Europe) alternated with cold summers and excessive rainfall. In winter violent storm-floods occurred, which entirely remoulded the coasts of the North Sea or frost set in so severely that the entire Baltic and even sometimes the Kattegat and the Skagerak were frozen. The lecturer showed that such phenomena may be ascribed to alterations in the oceanic circulation caused by the influence of the Moon and the Sun. Experiments carried on during the last four years at Borneo, in Sweden, have shown that the inflow of the undercurrent from the North Sea into the Kattegat—which brings the herring shoals in the winter to the Swedish coast—is oscillatory, the boundary surface of the deep water rising and sinking from 50 to 80 feet about twice a month. The phenomenon is governed by the Moon's declination and proximity to the Earth.

From astronomical data Prof. Pattersons concludes that the influence both of the Sun and of the Moon upon the waters of the ocean in winter about the time of the solstice must have been greater 600 to 700 years ago than at the present time. This must have caused a more intense circulation, of which we have conclusive evidence in the fact that the migrations of the

herring, which now only reach as far as to the Kattegat, in those centuries extended into the Baltic. The bank water or deep water of the Kattegat in winter time must then have attained a higher level and entered the Baltic through Crescend. The surface-layer must have been thinner, and as a thin surface-layer is much more easily cooled in winter and heated in summer than a thicker one, it is evident that the controlling temperature influences of the ocean must have been different at least in North and North-Eastern Europe, whose climate in mediæval time must have had, on the whole, a more continental character than now. In conclusion the lecturer showed that the hypothesis, first proposed by A. W. Ljungman in 1879, that the great secular periodicity of the herring fishery of Bohusland should agree with that of the sun-spots, is by no means incompatible with the phenomena here described, since the 14th century is noted in Chinese annals as an epoch of maximum solar activity, and since the sun-spot frequency curve of Wolfer can be reconstructed by harmonic analysis, using the Moon's apsidal and nodal periods as the basis of the analysis.

Memoranda for Observers.

Standard Time of India is adopted in these Memoranda.

For the month of June 1912.

Sidereal time at 8 p.m.

	H.	M.	S.
June 1st	12	38	49
,, *8th*	13	6	25
,, *15th*	13	34	0
,, *22nd*	14	1	36
,, *29th*	14	29	12

From this table the constellations visible during the evenings of June can be ascertained by a reference to their position as given in a Star Chart.

Phases of the Moon.

		H.	M.
June 8th	Last Quarter	8	6 a.m.
,, *15th*	New Moon	11	54 a.m.
,, *22nd*	First Quarter	2	9 a.m.
,, *29th*	Full Moon	7	4 p.m.

Meteors.

Date.		Radiant. R. A.	Dec.	Character.
May—June	...	235°	+9°	Rather slow
May—June	...	280°	+32°	Swift.

Planets.

Venus—Is a morning star. The position of this planet on the 15th of June at 8 p.m. will be R. A. 5 h. 9 m. 49 s. Dec. 22°-49′-4″ N. The time of its rising will be 4 h. 30 m. a.m. on the 16th June.

Saturn.—The position of this planet on the 15th of June at 8 p.m. will be R. A. 3 h. 42 m. 56 s. Dec. 17°-44′-44″ N. The time of its rising will be 3 h. 11 m. a.m. on the 16th June.

Mars.—The position of this planet on the 15th of June at 8 p.m. will be R. A. 8 h. 54 m. 44. s. Dec. 18°-48′-32″ N. The time of its setting will be 9 h. 32 m. p.m.

Jupiter.—The position of this planet on the 15th of June at 8 p.m. will be R. A. 16 h. 28 m. 40 s. Dec. 21°-1′-58″ S. The time of its setting will be 3 h. 55 m. a.m. on 16th June.

Notices of the Society.

Election of Members.

The attention of members is invited to Bye-Law No. 14, regulating the election of persons who desire to join the Society. It is hoped that those who are already members will induce others to join. Forms of application can be had from the Secretary, Mr. P. N. Mukherji.

Change of Addresses.

It is particularly requested that when members change their addresses, they will kindly notify the new address to the Secretary. The omission to do this is likely to cause the loss of the JOURNALS and other communications.

Telegraphic Address.

The address of the Society has been registered at the Telegraph Office, Calcutta. Telegrams should be addressed "Astronomy, Calcutta."

The Library.

A subscription list exists and several members in Calcutta have subscribed and enabled the Council to make a beginning with the Library. Other members outside Calcutta, however, have not, except in one or two cases, yet come forward, and as the Library will be one of the most important adjuncts of the Society, and will be available to members both in and out of Calcutta, those who have not yet done so are invited to help the Society in making progress with this important branch of the work. Suggestions as to useful books for the Library will also be welcomed by the Librarian.

A number of books have already been received and can be borrowed by members in accordance with the Bye-Laws.

The books available can be ascertained from the Assistant Librarian and a catalogue will be issued shortly. The reading room of the Society in the Imperial Secretariat is now opened for the use of members daily from 5 to 7 p.m., except on Wednesdays and holidays, and from 3 to 5 p.m. on Saturdays, unless that day is a holiday.

The Journal.

The following charges have been fixed for back numbers of the JOURNAL :—

For members.—Per copy 12 annas ; per volume Rs. 5.

The Star Chart.—As. 12 a copy.

For non-members.—Rs. 1-8 per copy.

The Star Chart.—Rs. 2 a copy.

Subscriptions.

Subscriptions for the current session fell due on 1st October 1911. Those who have not paid in their subscriptions are requested to remit them to the Treasurer without delay.

Papers for Meetings.

It is requested that drawings which accompany papers for reproduction in the JOURNAL may be made with Indian ink on white paper. This will insure a clear reproduction.

List of Instruments.

With a view to enable the Council to obtain a knowledge of the instrumental equipment of the members, it is requested that those members who possess any instrument suitable for astronomical work will kindly send details to Director of Instruments of its kind, size and power.

Meetings for the Session 1911-12.

ORDINARY MEETINGS.

25th June 1912.

The meetings will commence at 5 p.m. and, until further notice, will be held in the Imperial Secretariat (Treasury) Buildings.

Addresses of Officers.

Owing to inconvenience which has arisen from addressing the Officers of the Society at their private address, it has been decided to receive communications on the business of the Society in future as follows :—

	To
Money orders or letters containing money or cheques.	U. L. BANERJEE, ESQ., Office of the Accountant-General, Bengal, 3, Koila Ghat Street, CALCUTTA.
All other communications	(*Name*) ....Esq. (*Designation*) ....of the Astronomical Society of India, Imperial Secretariat (Treasury) Buildings, Calcutta.

It is requested that the communications may be addressed accordingly.

Officers and Council.

FOR THE SESSION 1911-12.

(1) *President* . .	. H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.
(2) *Vice-Presidents* .	. (1) COL. S. G. BURRARD, R.E., C.S.I., F.R.S.
	(2) J. EVERSHED, ESQ., F.R.A.S.
	(3) SREE RAJA A. V. JUGGA RAO BAHADUR GARU, F.R.A.S., F.A.I., F.R.M.S., F.A.S. & C.
	(4) H. H. THE MAHARAJA RANA BAHADUR SIR BHAWANI SINGH, K.C.S.I., F.R.A.S.
(3) *Secretary (Scientific)*	. DR. E. P. HARRISON, PH.D.
Do. (Business)	. P. N. MUKHERJI, ESQ., M.A., F.R.A.S., F.S.S.
(4) *Treasurer* . .	. U. L. BANERJEE, ESQ., M.A.
Directors of Sections—	
Lunar Section .	. H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.
Meteor Section .	. P. C. BOSE, ESQ.
Variable Star Section	. LIEUT.-COL. LENOX-CONYNGHAM, R.E., F.R.A.S.
Instrumental Director	. S. WOODHOUSE, ESQ.
Director of Classes .	. B. N. RAKSHIT, ESQ.
Librarian . .	. C. T. LETTON, ESQ.
Editor . . .	. J. J. MEIKLE, ESQ.

OTHER MEMBERS OF THE COUNCIL.

J. C. DUTT, ESQ., M.A., B.L.
F. W. HOWSE, ESQ.
A. T. MITRA, ESQ., M.A.
J. C. MITRA, ESQ., M.A., B.L.
C. W. PEAKE, ESQ., M.A.
SARODA CHARAN MITTER, ESQ., M.A., B.L.
W. J. SIMMONS, ESQ.
C. K. SIRCAR, ESQ., C.E., M.S.A., M.S.E.
W. A. LEE, ESQ., F.R.MET.S.
MISS ALICE MCLEOD.

The Journal of the

Astronomical Society of India.

VOL. II.] SESSION 1911-1912. [No. 8.

Report of the Meeting of the Society held on Tuesday, the 28th May 1912.

THE usual Monthly Meeting of the Astronomical Society of India was held in the Imperial Secretariat Buildings (Ground Floor), on Tuesday, the 28th May 1912.

H. G. TOMKINS, C.I.E., F.R.A.S., *President*, in the Chair.

S. C. GHOSH, M.A., Officiating *Secretary*.

Mr. Ghosh read the minutes of the previous meeting which were confirmed.

The following presents to the Society were then announced, and a vote of thanks was accorded to the respective donors :—

1. Monthly Notices of the Royal Astronomical Society (Vol. LXXII, No. 5).
2. Journal of the British Astronomical Association (Vol. XXII, No. 6).
3. Bulletin of the Astronomical Society of Barcelona for April 1912.
4. Rivista Di Astronomia Anno VI, No. 4.

5. Annuaire Astronomique Pour 1913.
6. The Collegian Nos. 1 and 2.
7. Annual Report of the Director, Kodaikanal and Madras Observatories for 1911, and Bulletin No. XXV.
8. Bengali Magazine "Bijnan."

The election at the last Council Meeting of the following gentlemen as members of the Society was then confirmed :—

1. MR. ASHUTOSH BANERJEE, M.A.
2. ,, HARELAL DHAR, B.A.
3. ,, SRISH CHANDRA MITRA, B.A.
4. ,, BHUJENDRA NATH CHATTERJEE, B.A.
5. ,, ABINASH CHANDRA BOSE, M.A.
6. ,, UPENDRA CHANDRA MITRA, B.A.
7. ,, DHIRENDRA NATH DAS.

The President then invited the members who had not signed the Roll to do so, and after this was done, he formally admitted them to the Society.

President.—Before proceeding any further I wish to refer members to Bye-Law No. 10 which lays down that at their next ordinary meeting in June the Council shall take into consideration the subject of the election of Officers and Council and decide upon a list of names to be recommended to the Society at the ensuing Annual General Meeting. This list, together with all such lists as have been duly transmitted under Bye-Law 9, shall be circulated among the members. Should the members wish to put in any other names in the list they are free to do so. I shall have the lists circulated as early as possible so as to enable the members to give the matter their attention.

The President then said that Dr. Harrison's Telescope was ready for use, and after Mr. Lee had kindly explained the way to use it, he and Dr. Harrison hoped that the members would recollect that it was given for them to use and not to lie in the Library to be looked at. He then called on Mr. Lee to explain the instrument.

Mr. Lee.—At the bottom of the tube is the concave reflector held in its place in the axis of the tube by three screws which are seen round the tube. The mirror has to be placed at right angle to the axis of the telescope and it is adjusted

in its place, so as to be exactly across the axis, by the three adjusting screws, at the bottom of the tube, which press on the back of the mirror.

Light, from the object to be viewed, comes into the telescope at its open end and is reflected back straight up the tube, converging to a focus. Before the rays reach a focus they fall upon a small flat mirror placed in the axis of the telescope, at such an angle that the rays are reflected out through the side of the tube and into the eye-piece. The eye-piece is an ordinary astronomical eye-piece.

The mounting is a kind of equatorial, by means of which one of the axes upon which the telescope turns is parallel to the Earth's axis of rotation, and as a celestial object moves in the sky the telescope can follow it by a single motion instead of having to make a zigzag as with the ordinary telescope mounting an alternation of little horizontal and vertical movements. There is a screw on the top of the mounting by which the telescope can be moved slowly in right ascension so as to follow a star quite slowly and continuously as it moves.

There is nothing difficult or abstruse about using a reflector, its chief difference to an ordinary person is the convenient position of the eye-piece so that one looks almost horizontally into it, and the observer does not need to lie down nor to crane his neck into an uncomfortable position, as with the ordinary refracting telescope, in order to observe an object high up in the sky. There is no necessity for special observing ladders and chairs, nor for hydraulic floors.

The President then asked the members if they had any questions to ask about the instrument, and expressed his hope once more that the members would make use of the instrument now that they had it, as the excuse hitherto had been that they had no instrument to work with. He hoped that they would take up certain lines of work, and suggested that it would be very pleasant for members to work in pairs so as to assist each other. Those who wished for help in selecting a line of work could obtain it by asking for it.

A vote of thanks was accorded to Mr. Lee for his description of the instrument.

The President then announced that there were three papers to be read that evening and referred to the paper by Mr. McInerney, on the construction of a Universal Sun Dial which was read at the last meeting, but which was rather difficult to understand owing to the absence of the slide to

explain it fully. He called on Mr. Simmons to read the paper again. This was done, and the lantern slide was shown on the screen. The President asked if there was any one who would like to ask any questions, and the members then accorded their thanks to Mr. Simmons for reading the paper.

Mr. Raman next read a very interesting paper on the "Diffraction of light and its relation to the performance of telescopes," illustrating it with a number of diagrams and lantern slides.

President.—I think several of us will be interested by what Mr. Raman has said to-night. Anybody who is used to Telescopes must be accustomed to the diffraction rings round the stars. In a perfect telescope there will be seen a star which looks like a pearl and round it one or two diffraction rings. I have never heard the explanation before of the intensity of the rings. It is most interesting, and I am sure we shall all look forward to reading Mr. Raman's paper in the Journal. I would ask you to thank him for the trouble he has taken in presenting us with this very useful and interesting paper and in making the slides for us.

The thanks of the members were then accorded to Mr. Raman.

President.—I would now ask Mr. Bell to read his paper on the recent Solar Eclipse in England.

A photograph of the eclipse which was taken in Lincolnshire was shown on the screen by means of lantern slides.

The President asked the members if they had any questions to ask regarding the paper or the photographs.

Mr. Simmons.—One interesting point to note is that the last eclipse took place in 1858, which is a period of 54 years (equal to 3 Saros) between the last eclipse and this one in April, and if you calculate 54 years from now you will have another eclipse in 1966.

President.—The only photograph of the eclipse we have got is the one shown by Mr. Bell which was taken by his son.

He then showed some more lantern slides on the screen of the Planets, Jupiter and Saturn.

The meeting was then adjourned to the last Tuesday of June. This will be the last meeting of the Session till the meeting in October.

The Diffraction of Light and its Relation to the Performance of Telescopes.

BY C. V. RAMAN.

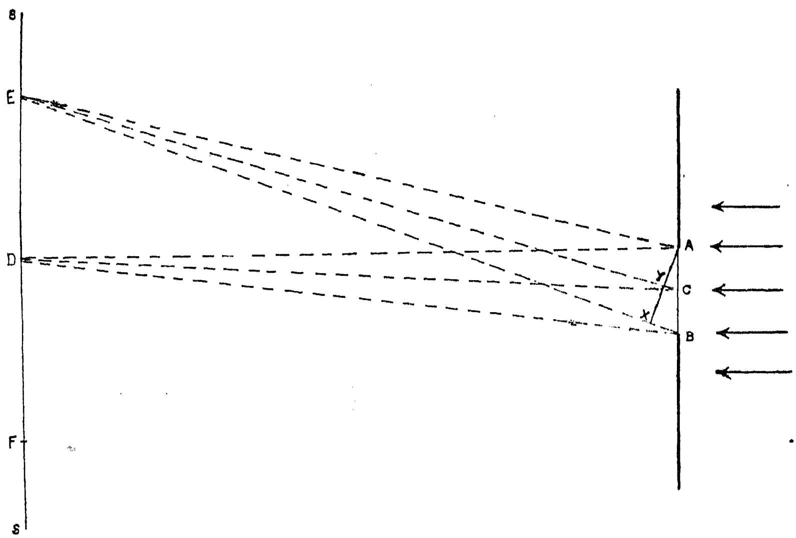
I propose in the present paper to discuss (with a few illustrations from my own work on the subject) some phenomena of the diffraction of light, and the fundamental principles by the aid of which they can be rendered intelligible.

I shall also discuss and emphasise the importance of the part played by diffraction in telescopic work, though here I have necessarily to follow largely the lines laid down by pioneer investigators like Lord Rayleigh.

To begin with, we may consider the case of a reflecting telescope which is directed towards a star at a sufficient altitude and let us put aside for a moment all trouble due to atmospheric conditions. We have coming in into the telescope a stream of light from the star in one definite direction, within very close limits. The text-books say that if the figure of the mirror is a paraboloid of revolution with its axis in the direction of the star, the light passing into the telescope is condensed into a point at the focus of the mirror. This seems evident from the principle of the reflexion of light, since at each point at which the light falls upon the mirror the normal to its surface bisects the angle between the join of that point with the focus and a line parallel to the axis of the mirror. Now the question which both the physicist and the practical astronomer will ask is this : Is all the light really condensed into a point ? A little consideration of physical principles will show that it cannot be so, even if the figuring of the mirror were theoretically perfect. Such a condensation would obviously involve a sudden transition from a very large illumination at the focus to zero illumination at immediately contiguous points. Such a state of things seems *a priori* extremely unlikely on any physical theory of the propagation of light. On the analogy of sound-waves, which as we know can go round or over a brick wall of moderate size without entirely ceasing to be audible, it seems evident that a certain amount of bending or spreading out is inevitable. In the case of a telescope, the entering beam of light is ordinarily limited by a circular aperture and what we get at the focal plane of the telescope as the image of a point source is a diffraction pattern

which consists (*vide* Fig. 1 in the plate) of a central bright disc followed by successive dark and bright circular rings of greatly reduced intensity. In actual astronomical work, the second and third bright rings cannot ordinarily be seen because of their excessive faintness. They can, however, be observed in laboratory work, and if white light is used the rings are coloured.

It is not difficult to make out in a general way why we should get these rings. It is well, however, to begin with a simpler case, *i.e.*, when instead of a circular aperture we have a long narrow rectangular slit limiting the beam of light. Let A B in the diagram represent the width of the rectangular slit. A parallel beam of light is incident normally on one side of the plate in which the slit is cut, and of this beam all



except the portion that can pass through the slit is cut off by the plate. We can now consider the effect produced by such of the light as actually gets through at a screen S S placed at a great distance from the slit (this is shown in the diagram much too near the screen for the sake of space and clearness). If there were no diffraction, we would evidently have on the screen merely a narrow bright strip of light identically similar to the slit in width and length. What we actually get is a broadened central bright band parallel to the slit with alternate dark and bright bands of diminishing intensity situated symmetrically on either side of it. We may explain the formation of these bands in the following way. Let C be

the mid-point of the aperture A B. We may conceive that the two halves of the aperture A C, C B are further divided up in the same way into a very large number of equal *elements*. We may properly assume that each of these small elements acts as a source and sends out waves on its own account in all directions into the region behind the aperture. To find the net result at any place we have to add up the effects of these individual waves and strike a balance. In working this out it is convenient to consider the elements in pairs, *i.e.*, the first one in A C and the first on C B, and so on. The waves sent out by the two elements of a pair intersect all over the field. The effect of these two sets is somewhat analogous to what we should have on the surface of mercury in a trough if we had two needles attached side by side dipping into the liquid and moved rapidly up and down by an attachment to the prong of a vibrating tuning fork. Both needles would act as centres of disturbance sending out circular ripples on the surface of the mercury and by their criss-crossing we would have a regular interference pattern on the surface. In certain regions the crests of one set of ripples would always coincide with the troughs of the 2nd set and the troughs of the former would coincide with the crests of the latter. The mercury surface would remain practically quiescent in these regions. In other regions the crests of one set of ripples would coincide with the crests of the 2nd set and the troughs of the former with the troughs of the latter, and we would have ripples of double amplitude travelling along these regions. We have an analogous effect with the light waves.

If D is the point on the screen exactly opposite the slit, and on the assumption that the former is at a sufficiently great distance from the latter, it is evident that the length C D differs from A D by a quantity which is too small to be appreciable, and it is clear that the elements at A and C produce practically identical results at the point D. This is also the case in respect of all the other elements in the aperture A B, and as the result we have bright illumination at the point D. If, however, we consider the effect at a point removed to one side, *i.e.*, say at E, the case is different. The distance C E is greater than A E by the length C Y. The crests of the waves from the element at C therefore lag behind those of the waves from A, and we would have appreciably less illumination than at D. If the angle D C E is of such magnitude that the distance C Y is half a wave-length, *i.e.*, the distance between a crest and a trough, the wave from the element at C just annuls the wave from the element at A, and this is also obviously true of each pair of elements in the two halves of the

aperture and we would have complete darkness. E would then be the position of the 1st dark band. Similarly on the other side of D, F would be the position of the 1st dark band if D E = D F. If we go further out on either side beyond E or F, the elements would cease to annul each other and we would have a restoration of the light, but in greatly diminished intensity, since now the different pairs of elements do not all work together. The formation of the successive dark and bright bands can be traced in this way. The angular width 2 θ of the central bright band can easily be calculated since C Y $= \frac{\mathcal{L}}{2}$ where $\mathcal{L}$ represents the full wave-length.

Putting A B $= a$, the equation is

$$\mathrm{S\,in}\ \theta = \frac{\mathcal{L}}{a}.$$

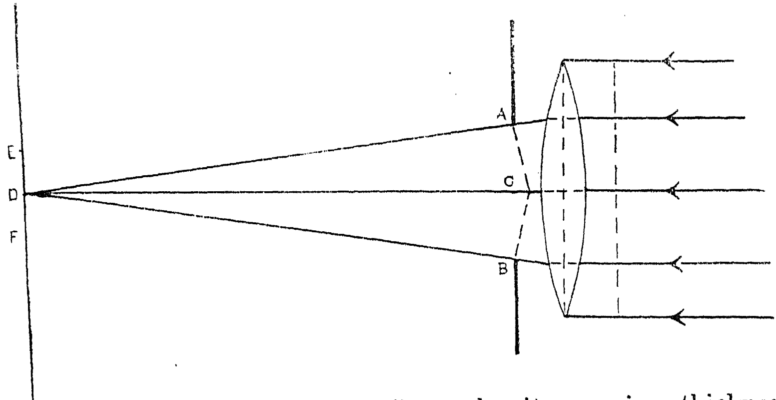
If we now substitute a circular aperture of diameter a for the rectangular slit of the same width, it is evident from considerations of symmetry that we would have circular rings instead of parallel bands on the screen, but the angular width of the 1st dark ring is somewhat greater than that given by the formula for the rectangular slit. The reason for this is easily surmised. For the width of the bands increases when the aperture is decreased and a is only the *maximum* width of the circular aperture as measured on a diameter. Along parallel chords the width is less. A full mathematical treatment shows that in the case of the circular aperture the angular radius of the 1st dark ring is given by the formula

$$\mathrm{S\,in}\ \theta = 1{\cdot}22\frac{\mathcal{L}}{a}.$$

In the discussion given above it is assumed that the screen is at a sufficiently great distance to give us these rings in perfection. When, however, the aperture is large, the distance at which the screen would have to be held would be unmanageable and the simplest thing would be to put in a lens just behind the aperture to focus the diffraction pattern on to the screen, which should then be placed in the focal plane of the lens. We may regard the object-glass or reflector of a telescope as serving this purpose and the angular diameter of the rings seen in the focal plane would be determined by precisely the same formulæ.

Another instructive way of regarding this question would be to commence with considering the effect of the object-glass. The function of an object-glass is evidently to convert the plane parallel waves arriving at it into converging spherical waves,

which come to a focus at their centre, as shown in the diagram.



This the object-glass effects by its varying thickness from point to point, the central parts of the glass retarding the progress of the waves to a greater extent than the marginal areas with the result that on emergence they are spherical and convergent. The distances D A, D C, D B are equal, D being the centre of the convergent wave. To find the effect at any point on a screen, held in the focal plane, we have now to divide up the spherical surface A C B into little elements and consider the interference of the wavelets proceeding from the different elements, which depends as before on the difference of their distances from the point D and the further treatment is on much the same lines as that given before. We have the ring or band system round the point D as centre, this being the position where the waves from all the elements conspire and produce the largest effect.

A numerical example would be useful here. The reflecting telescope presented by Dr. Harrison to the Society has an aperture of 4 inches. The angular radius of the 1st dark ring in this case is given by the formula

$$\theta = 1{\cdot}2\,\frac{\lambda}{a}$$

λ for yellow light is about $\dfrac{1}{50{,}000}$ inch, and a is 4 inches

$$\theta = 1{\cdot}2 \times \frac{60 \times 60 \times 180 \times 7}{22 \times 200{,}000} \text{ seconds of arc}$$
$$= 1{\cdot}2''$$

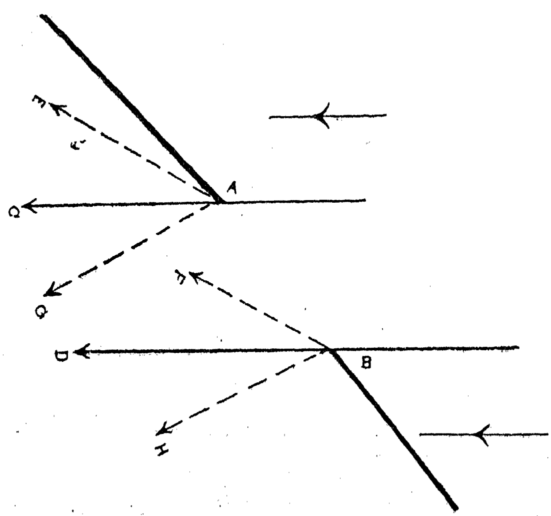
The diameter of the central disc is double this, *i.e.*, $2{\cdot}4''$

In the cases that have been considered in the foregoing, the apertures were taken to be held in a position normal to the direction of the beam of light whose width they restricted.

It is evident that it is also possible for the incident beam of light to be restricted in width by an obliquely-held aperture and such cases are fairly common in spectroscopic work. In the case of the rectangular aperture, the first effect of inclining it is to increase the width of the bands while their general character and symmetry remain unaltered. The reason for this is clear. With an obliquely-held slit, the effective width of the beam of light entering the telescope is less than when the aperture is held normally and the width of the bands is therefore necessarily increased in inverse proportion.

When the obliquity is very considerable, the character of the diffraction bands undergoes certain modifications, which are not only interesting in themselves but throw much light upon some matters of fundamental principle. One effect is that the diffraction pattern becomes unsymmetrical, the bands on one side of the system becoming much broader than those on the other side. This is well shown by Figs. 5 and 6 in the plate. In taking these photographs, the diffraction pattern was obtained by reflecting the beam of light into the telescope by a rectangular mirror, obliquely held, the source of light being a distant vertical slit, the direct image of which broadened by photographic halation also appears in the photographs. These unsymmetrical bands can, of course, also be obtained by transmission through an obliquely-held aperture, the two arrangements being equivalent in theory.

The asymmetry can be explained in the following simple manner :—



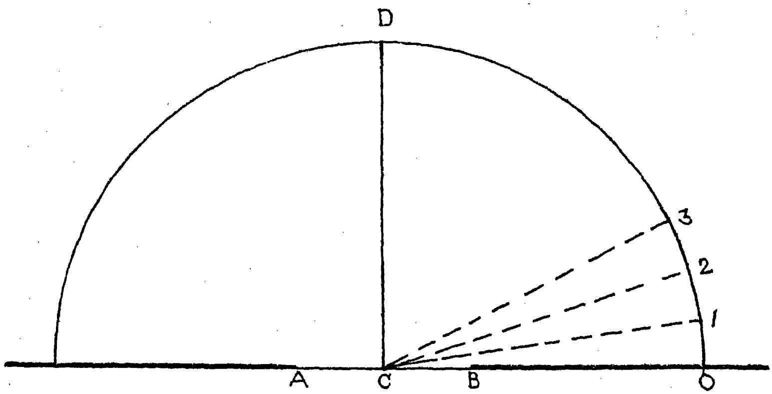
In the diagram A B is the aperture on which the light is obliquely incident. I have already explained that in the direction of the incident beam (*i.e.*, A C or B D in the diagram) we get the maximum light in the diffraction pattern.

To get to the first dark band on either side, the angle turned through must be such that a wavelet from an element at B gains or loses a wave-length over a wavelet from A. From the figure it is obvious that to gain a wave-length on the side B H a smaller angle need be turned through than is necessary on the side B F to lose a wave-length, and the angular width of the bands on the right-hand side is therefore less than the width on the left. The number of bands on the latter side is also limited.

With a circular aperture held at a moderate obliquity we get a system of elliptical bands (Fig. 2 in the plate), since the projection of the aperture, *i.e.*, its effective shape itself becomes an ellipse. At very oblique incidences the bands become unsymmetrical, *i.e.*, are elongated on one side in preference to the other. This is clearly shown in Fig. 3 in the plate. Theory shows that in this case, the dark and bright rings take the shape of Cartesian Ovals.

Figs. 5 and 6 in the plate which relate to diffraction at very oblique incidences show another effect that is really of fundamental importance. It will be observed by comparing corresponding bands on either side of the pattern that they are less in intensity on the side on which they are broader than on the side where they are narrow. In order to explain this effect, it is necessary, as I have shown elsewhere, to consider the peculiar character of the waves which in the preceding treatment we have assumed the *elements* of the aperture to send out and which by their interference produce the observed diffraction pattern. In the foregoing discussion I said we may reasonably assume that the elements send out waves (or wavelets rather) in all directions into the region behind the aperture. But do they send out wavelets with equal *strength* in all such directions ? This point, important as it is, had never been worked at from an experimental point of view. Experiments on normally held apertures cannot throw any light on the subject. For in such cases, the diffraction pattern is formed at regions contiguous to the apex of the hemispherical wavelets sent out by the elements in the

direction C D in the diagram.



The intensity at D due to any one element is obviously a maximum and at any neighbouring points it cannot differ very appreciably. If, however, we work at very oblique incidences so that the diffraction pattern is formed in the region marked 0, 1, 2, 3, we should get some "obliquity" effects as I have called them. For, at the point 0 the amplitude must be zero and at any one of the points 1, 2, 3 it must be finite and increase as we go up. A diffraction pattern formed at such an incidence should obviously show a progressive increase in brightness from one side to the other superposed on the fluctuations caused by the interference of the wavelets. That the effects actually observed are due to such a cause, I have shown by photometric determination of the relative intensity of corresponding bands on either side of the pattern (using the well-known method of "revolving sectored-disc"), and the mathematical law of obliquity proposed by me has been fully verified.

The diffraction of light is of great importance in practical telescopic work. If, as we have seen above, the image of a mathematical point is not itself a point but a diffraction pattern, it is evident that the telescopic image cannot be an exact representation of the object viewed. Much detail is necessarily obliterated. The simplest case is that of a double star. A photograph of the diffraction pattern due to two adjacent point sources as seen through a circular aperture is shown in Fig. 4 in the plate. It is seen that the two discs have run together into a slightly elongated patch and, except probably under the most favourable atmospheric conditions, it would be impossible to detect that an object of this kind was a double star, or a triple star or one star, by itself. Herein lies

the principal advantage of telescopes of large aperture. As the angular diameter of the diffraction disc due to a point source decreases in inverse proportion to the aperture, the resolving power increases *pari passu* provided that the figuring of the mirror or lenses continues perfect.

The same principle applies also in planetary work. Other things being the same, the larger the aperture the finer the detail that can be revealed by the instrument. This point is easily verifiable in laboratory experiments in which a disc with alternate white and black strips ruled on it is observed or photographed through an aperture with adjustable jaws. As the width of the aperture is gradually reduced, the white strips become fuzzy and broaden out, and after a certain stage completely obliterate the black areas in spite of the fact that the lens performs best with the smallest apertures.

On a small scale, this experiment can be made by the readers of this Journal with very simple apparatus and without any telescope at all. A piece of wire gauze and a cardboard in which two holes have been pierced with a pin are all that is required. One of the holes in the card should be larger than the other. The piece of gauze should be placed against a window so as to be backed by the sky, or in front of a lamp provided with a ground glass or opal globe. You then look at the gauze through the pinholes. Using the smaller pinhole and gradually drawing back from the gauze, you find that you lose definition and ultimately all sight of the wires, though there is light enough for the purpose. The distance at which this will happen depends upon the fineness of the gauze and the size of the pinhole: 5 or 6 feet will probably be sufficient. If, when looking through the smaller hole you have just lost the wires, you shift the card so as to bring the larger hole into operation, you will see the wires again perfectly.

In closing I should mention that Prof. Lowell holds that in planetary work there is no use increasing your apertures beyond a certain point, *i.e.*, say 20 or 25 inches, the reason advanced by him being the trouble from atmospheric conditions. If this point could be attacked and decided mathematically there would be good work done, I think.

Eclipse of the Sun.

BY J. C. BELL.

In view of the interest attached to the eclipse of 16th-17th April 1912, I will endeavour to say a few words on the subject.

A Solar Eclipse can only happen when the Moon is at or near one of its Nodes and also in conjunction with the Sun.

Eclipses of every sort repeat themselves at the end of each Saros.

A Saros is a period of 18 years and 12 days when the Sun and Moon find themselves in much the same position as they did at the previous eclipse.

They will not be in exactly the same position, owing to two causes, *viz.* :—

(*a*) Difference of eight hours during each Saros.

(*b*) The change in the Moon's line of motion in the meanwhile.

The path of the shadow will thus pass further north or south.

Total eclipses of the Sun happen with tolerable frequency so far as regards the Earth as a whole, but they are exceedingly rare at any given place, and under the most favourable circumstances the breadth of the track of totality across the Earth is not more than 170 miles. On the last occasion the Sun rose eclipsed in Venezuela, and after crossing Guiana, the line of central eclipse left the South American Continent at a point west of Cayenne.

It traversed the Atlantic in a north-easterly direction and came to land again at a point in the north of Portugal.

The line of centrality then passed over the north-west of Spain, the Gulf of Gascony, the coast of France near the Sands of Olonne (Vendée) and thence to Paris, passing west of the French capital, but east of St. Germain.

It continued by Hamburg, the Baltic, St. Petersburg, and ended its journey in Russian Asia.

It will thus be noticed that the line of central eclipse ran very obliquely from south to north, beginning its course in Venezuela and ending in Russian Asia.

The longitudes and latitudes of the line of central eclipse varied from $0°\text{-}17'{\cdot}2$ to $10°\text{-}35'{\cdot}0$ longitude and $40°\text{-}5{\cdot}7$ to $53°\text{-}11'{\cdot}4$ latitude.

If we look at the diagram about eclipses in any text-book, we see that if the Moon is near the Earth, that is at perigee or nearly so, when she eclipses the Sun, the eclipse will be total, and if the eclipse happens quite at perigee the Moon's shadow on the Earth will be large.

On the other hand, if the Moon be comparatively far from the Earth, the eclipse will be annular.

In April the Moon was in apogee on the 9th and in perigee on the 22nd, so the eclipse happened about midway between these dates, which defined approximately the limit between totality and annularity.

The type of eclipse was therefore annular and total for about 6 seconds whilst crossing Portugal and Spain only.

A partial eclipse was seen from all places in the British Isles.

A photo taken by one of my sons from South Lincolnshire and reflected on the screen, will give an idea of the eclipse as seen at that place on the 16th April 1912.

If any enterprising person went up in a flying machine on the 16th-17th April, he must have seen the whole of the Moon's shadow at a glance, as a dark spot on the Earth's surface.

The special feature of the eclipse was that the shadow cast by the Moon just covered the Sun's disk and no more.

This is of rare occurrence, when we recall the fact that the Sun has about four hundred times the diameter of the Moon and is also four hundred times as far from us as the Moon.

In plain language, for this to happen, the Moon must be in one particular spot between the Sun and the Earth, and this, as will be readily perceived, will take place very occasionally.

The Corona was on outstanding feature, and its observation should lead to valuable scientific results, as apart from the fascination of following closely an eclipse, it enables the scientist to study the Sun's Corona, and to determine through the aid of the spectroscope the substances of which it is formed.

The exact nature of the Corona is still in doubt, and it is certainly a complex phenomenon.

The next total eclipse of the Sun will take place on 10th October 1912, but unfortunately it will not be visible in India.

It will be visible only in South America.

Extracts from Publications.

Protection of high observatories from lightning.—In a recent number of the "Comptes Rendus," J. Vallot gave an account of a number of cases where observatories at high elevations have been struck by lightning within the last few years, with much damage to apparatus, and danger to the observers. In one case it was a wooden observatory sunk into the snow, and unprovided with lightning conductors. But even observatories provided with them have not been spared. A good earthing is difficult, as snow and frozen soil conduct badly. In an observatory erected on snow, cables were laid to the bare rock 100 yards away to provide an earthing. But evidently the long cables were not able to conduct away the large quantity of electricity passing in the lightning.

The *Observatoire des Bosses, on Mont Blanc*, has, on the other hand, never been struck by lightning. In this case the protective device is the following : Four lightning conductors with several points each are erected on the roof and mutually connected. Each is also connected with the rock by means of an iron wire ½ cm. thick, ending in a coil. The whole observatory is covered with thin copper plates, connected to the lightning conductors, and to the stove-pipe. The whole arrangement constitutes a Faraday cage, and has effectively protected the observatory for thirteen years, the lightning always finding ample conductivities to render it innocuous.

An efficient protective device for observatories built on deep snow has, however, yet to be devised.

[*English Mechanic.*

Visual Observations of Red Variable Stars. (*By J. A. Parkhurst*).—Inquiries from several members of the Variable Star Section lead one to mention again some points in regard to the observations of these troublesome stars. These points have appeared before in "Popular Astronomy," but they will bear repeating.

(1) Punch's famous advice to those about to marry—"Don't" will apply very well to observers of very red stars, until they have accumulated a considerable experience with the easier, less highly coloured stars. But, assuming that difficulties will not deter the industrious and courageous members of the section, the following suggestions are offered.

(2) If a white and a red star appear equally bright in a certain field, they will change their relative brightness with change of conditions as regards (*a*) aperture used, (*b*) altitude, (*c*) haze or moonlight, (*d*) personality of observers, (*e*) duration of steady gaze, (*f*) angle between the line joining the stars and that joining the eyes (this last change will be apt to affect stars of any colour). Taking the points in order—

(*a*) An increase in aperture, giving more light, will make the red stars appear relatively brighter. A decrease will have the contrary effect.

(*b*) Change in altitude will have a complicated effect. For example, a decrease in altitude would make the red star lose in brightness on account of greater general absorption, but this might be more than balanced by the less amount of selective absorption for the red rays.

(*c*) It is hard to predict the direction of the effect of haze and moonlight, but they should be avoided.

(*d*) Eyes vary greatly in their sensibility to red rays, differences exceeding half a magnitude being not uncommon.

(*e*) Gazing steadily at a red star, it will usually appear to increase in brightness for some seconds. A good rule would be to gaze steadily till this increase ceases before making the estimate.

(*f*) The line joining the stars to be compared should be parallel to the line of the eyes. If two stars appear equal in this position, then if the head be rotated 90° the lower star will appear to most eyes about half a magnitude brighter, though to some observers there is little or no change.

If the precautions under (*a*), (*b*), (*c*), (*e*) and (*f*) are followed, some experience will enable the observer to get a consistent curve for his own eye; but on account of (*d*), his curve will not necessarily bear any definite relation to that found by another observer. Therefore it is not advisable to form a composite curve for the work of different observers, until the relation between their personalities has been determined. These considerations have led the writer to prefer photographic methods since a proper choice of plates and colour-filters will give both photographic and "visual" magnitudes free from the above difficulties except (*b*). A statement of the magnitude of a red star, as observed with the eye,

is not complete unless the conditions mentioned under (*a*), (*b*), (*c*), (*d*) and (*e*) are specified; and no longer holds if any one of the conditions is changed.

Yerkes Observatory, March 1912.

[*Popular Astronomy.*

A Question on the Capture Theory. (*By N. W. Mumford*).—Below may be found a very brief summary of Prof. See's monumental quarto volume on Cosmogony, concluding with an apparent exception to his theory.

The matters of greatest interest brought forward in the volume are; the theory of a general prevalence of a resisting medium in space, the assumption of the existence of such a medium in the typical or spiral nebulæ, and the tracing of the evolution of the solar system from a nebula of that class.

The author undertakes to show how the innumerable points of condensation in the vast nebular coils must revolve about the central nucleus, gradually uniting with each other under the force of gravity, and producing comparatively small globes or planets, whose orbits are reduced in size and rounded under the secular effects of the resisting nebulous medium. In the solar system this process is said to have practically cleared the interplanetary spaces of nebulous matter and to have evolved a highly stable cosmical figure, but doubtless one very far from unique among the millions of single suns. Among the smaller masses in the original nebula certain proportion would be captured by the bodies of planetary size and permanently held, owing to the force and the effects of the resisting medium. All moons captured in this way would not necessarily revolve about their primaries in the same direction. The prevailing rain of meteorites and cosmic dust during the clearing up process would produce planetary rotation in one direction. Other so-called moons, not captured by the planets, take up regular planetary orbits, becoming asteroids, and still other bodies, visitors from the region of the outer shell of the original nebula describe nearly parabolic orbits (except when such orbits are transformed by the action of large planets) approaching the central luminary at long intervals, and appearing as comets.

The stars themselves would appear to be condensations of nebulosity, adding to their own bulk by accretions of enormous amounts of waste matter attending them, and often

appearing as double, triple and multiple suns, when two or more dominating centres of condensation sweep up the nebular strays and settle into orbits about their common centre of gravity. The variable stars would seem to be those pairs whose plane of revolution lies in line with one sun, and whose orbital movements, when the plane is thus situated, would produce eclipses; or else pairs revolving in long ellipses, about a common centre, that appear to encounter considerable resisting medium on close approach, causing them to flare up or fluctuate in brightness. New or temporary stars would seem to be those produced by collision between a planet, a satellite, or large comet and its central sun, causing a sudden conflagration; or one of the dark bodies of planetary size wandering in space, might enter a small nebula, the result being the blazing forth of a new star. The author regards the collision between sun and sun as a possibility so excessively remote that by the law of chances it practically never occurs.

The clusters of stars would appear to be the result of many condensations in nebulæ of extraordinary extent, whose combined power of gravitation may attract neighbouring suns into the mass; and the more diffuse star clouds seem to be gathered in somewhat the same way, but without regularity of form or condensation towards a common centre. The galaxy would appear to be the grand aggregate of nearly all the star clouds and clusters, spanning the heavens as an arch or girdle that embraces the visible universe. This stratum of stars is supposed to extend outward in its plane indefinitely. The existence of the coal sacks receives no satisfactory explanation.

The maintenance of the balance in the making and unmaking of the suns is thus described :—" On the one hand, nebulosity in the finest known state is expelled from the stars and drifts hither and thither through the universe, till it collects into cosmical clouds or nebulæ; on the other hand, these nebulæ in turn condense and form fixed stars surrounded by cosmical systems. This is the inevitable outcome of the condensation of the cosmical dust expelled from the stars; while the dust collecting into nebulæ is originally dispersed by the intensity of repulsive forces which may be traced to the high temperature and intensity of the light and electric forces operating in the stars. When the nebulæ condense into stars, it is probable that by an unknown circulatory process they again drift back towards the medial plane of the galaxy. Thus, there is an expulsion of dust from the starry stratum,

and a subsequent recovery of this matter in the form of mature stars. We may regard this cyclic process as perhaps the greatest of all the laws of nature." Attention is called to the recognised affinity of the majority of the nebulæ to the poles of the galaxy.

In this briefest possible summary, the steps cannot be traced showing how the author arrives at his various conclusions. Each detail of the structure of the heavens is analyzed with one important exception, the dark stars. Casual mention is made of "dark bodies of planetary size wandering in space," but the opaque non-luminous bodies comparable to the sun in mass are not considered.

We have every reason to believe that the dark stars are exceedingly numerous. Hitherto the study of stellar evolution has concerned itself very largely with the rise, culmination, wane, and extinction of the suns. The new astronomy was lately born and has made a vigorous growth under spectroscopic analysis. In at least sixty cases dark stars may be all but observed telescopically by their passage over the face of luminous suns, producing variables of the Algol class. Naturally different degrees of darkness, down to the absolute, prevail among such stars. There is scarcely an observer of the heavens who has not committed himself to the prevalence of numerous dark bodies, in all regions of the sky, and to the proposition that such bodies were once self-luminous. It has been stated, by Prof. Stoney for example, that the dark bodies far exceed in number the visible stars. Who is bold enough to assert that the light of each sun is from everlasting onward to infinity? It is as safe to say that each star runs its course to darkness as it is to trace the rise of each from a nebulous cloud; and the latter proposition Prof. See takes pain to demonstrate. But the revivifying of dead suns through collisions he denies nor is any discussion offered on the existence of such bodies.

A little consideration of the facts forces the alternative, either that the dark stars have some means of rejuvenation untouched upon by Prof. See or else that the cycle pointed out, from star to nebula and from nebula back to star, is inadequate for the maintenance of the visible universe.

The dark stars form a considerable class. Their ranks are recruited by the waning and extinction of light-giving bodies. They must steadily increase in numbers, if, with the author, the absence of means of rejuvenation is admitted. The energy of suns is imparted to the waste places of space in nebulous clouds, from which new suns are born; but

the givers of light and life, the organized stars, have lost something by the process ; and the loss is cumulative ; therein the argument is briefly expressed. It is immaterial how many new suns are born from nebulæ, all must trace back their origin to the light-giving stars. The loss of energy in these latter is irrevocable ; they must go through the process of waning and decay to darkness. Their offspring, assembled near the galactic poles, may eventually take their places, in their turn only to sink to darkness, after contributing their share to newer nebulæ. The number of the nebula must steadily decrease, with the extinction of parent stars, until they cease their function of fresh star formation, on account of the loss of repulsive forces in the waning and dead suns. Time only stretching into eternity is necessary to complete the process, and of this, the past is quite as immeasurable as the future

Therefore, owing to the inadequacy of the cyclic movement, from stars to nebulæ and back again for maintaining a balance in the making and unmaking of suns, the conclusion must be drawn, either that the heavens in the past were much brighter than at present, and will steadily decrease in brightness, a proposition that postulates an origin and goal that eludes imagination, or else that the dark stars do enjoy a process of rejuvenation. The latter conclusion only is tenable.

[*Popular Astronomy.*

On the Nature and Origin of Sunspots. (*By W. F. Carothers*).—There are some lines of evidence bearing upon the nature and origin of sunspots which I have never seen advanced and I present them herewith. In so far as my remarks are based upon personal observation they are limited to visual phenomena of the past three years. The first half of this period I used a Bardou $2\frac{5}{8}$ inch telescope, while from April 1910 to date the observations have been made with my new and incomparable Clark six inch refractor. During the year 1909 I recorded 80 observations of the sun on separate days ; during 1910, 202 such observations and up to date this year 140.

I refer specially to the hypothesis that sunspots are caused by downpours of cooler vapours from upper strata of the solar atmosphere.

I suppose it is well established that these upper strata have shorter periods of rotation than has the photosphere. This seems to be due to the general contraction of the sun, the outer envelopes bringing in with them their greater velocities. For

instance, if the earth should be brought in to revolve around the photosphere, retaining her present orbital velocity, she would make the circuit in less than two days when the photosphere requires 26 days and upward.

These considerations being true we should expect the spots to exhibit tendencies toward shorter periods than that of the photosphere if they are downpours of vapour falling from more rapidly moving upper strata. Now observation shows that the principal spot in a group and the larger end of the familiar pear-shaped spots take the lead, and, since it is here that we should look for the greater volumes of the descending matter, here also we should expect to see the principal forward momentum reveal itself, and therefore observation sustains the hypothesis in this respect.

Again groups and related spots approximate an east and west formation—as if strewn along from the more rapidly moving upper strata. It may be that this could be explained as a general effect of equatorial acceleration on other hypotheses, and it is not so convincing as the other but it should not be overlooked.

Then, too, the approximately round form of the spots accords with the theory under consideration. If we regard the photosphere as a fiery ocean of vapour, there would be a horizontal pressure against the invading downpours, which would be equal from all sides, thus giving the spots their generally round form. In such case the spots would persist in due proportion to the relative strength of the two forces, and if the downpour should slacken, or if the ocean pressure should increase, the spot would be overcome and effaced.

In this connection I have considered by itself the probable effects of an increase of solar temperature. It would undoubtedly increase the upward pressure of the lower strata, above the photosphere thus tending to prevent the downpours and to lessen the number of spots, and, at the same time, I think it would increase the horizontal pressure of the photosphere before mentioned, thus tending to shorten the lives of such spots as might form.

Of course amateur observations for so short a period cannot be more than suggestive, but if an examination of adequate records should establish it as a fact that the duration of sunspots is relatively shorter during periods of spot minima, that fact would be highly significant, not only with reference to the nature and origin of sunspots, but with reference to the

current problem of variation in the solar temperature, indicating that the temperature of the sun is greater during the spot minima.

This, in turn, would solve the puzzling phenomena of the spot minima and maxima, demonstrating that they are due to periodic variations in the solar temperatures.

[*Popular Astronomy.*

Memoranda for Observers.

Standard Time of India is adopted in these Memoranda.

For the month of July 1912.

Sidereal time at 8 p.m.

				H.	M.	S.
July 1st	...	...	...	14	37	5
,, *8th*	...	...	...	15	4	41
,, *15th*	...	...	...	15	32	17
,, *22nd*	...	...	...	15	59	53
,, *29th*	...	...	...	16	27	29

From this table the constellations visible during the evenings of July can be ascertained by a reference to their position as given in the Star Chart.

Phases of the Moon.

				H.	M.	
July 7th	Last Quarter	...	...	10	17	p. m.
,, *14th*	New Moon	...	...	6	43	p. m.
,, *21st*	First Quarter	...	...	10	48	a. m.
,, *29th*	Full Moon	...	...	9	58	a. m.

Meteors.

Date.	Radiant. R. A.	Dec.	Character.
July 6th—August 22nd	284°	–13°	Slow, Trains.
,, 15th — 31st	23	+43	Rapid, Streaks.
,, 6th—August 16th	315	+48	Rapid.
,, —August	269	+48	Slow, Trains.
,, 15th — 28th	304	–10	Do. do.
,,	22	+22	Rapid, Streaks.
,, 25th—Sept. 15th	48	+43	Do. do.
,, 27th — 31st	339	–11	Slow, Trains.
,, —Sept.	335	+73	Rapid.
,, —Oct. 8th	30	+36	Rapid, Streaks.
,, —Oct.	310	+79	Slow.
,, —August	339	–27	Slow, Trains.

Planets.

Venus.—Is an evening star. It sets about 12 minutes after sunset on the 15th July.

Saturn.—The position of this planet on the 15th July at 8 P.M. will be R. A. 3 h. 56 m. 28 s. Dec. 18°-24′-51″ N. The time of its rising will be 1 h. 25 m. A.M. on the 16th July.

Mars.—The position of this planet on the 15th July at 8 P.M. will be R. A. 10 h. 6 m. 23 s. Dec. 12°-50′-33″ N. The time of its setting will be 8 h. 34 m. P.M. on the 15th July.

Jupiter.—The position of this planet on the 15th July at 8 P.M. will be R. A. 16 h. 17 m. 6 s. Dec. 20°-40′-53″ S. The time of its setting will be 1 h. 46 m. A.M. on the 16th July.

Notices of the Society.

Election of Members.

The attention of members is invited to Bye-Law No. 14, regulating the election of persons who desire to join the Society. It is hoped that those who are already members will induce others to join. Forms of application can be had from the Secretary, Mr. P. N. Mukherji.

Change of Addresses.

It is particularly requested that when members change their addresses, they will kindly notify the new address to the Secretary. The omission to do this is likely to cause the loss of the JOURNALS and other communications.

Telegraphic Address.

The address of the Society has been registered at the Telegraph Office, Calcutta. Telegrams should be addressed "Astronomy, Calcutta."

The Library.

A subscription list exists and several members in Calcutta have subscribed and enabled the Council to make a beginning with the Library. Other members outside Calcutta, however, have not, except in one or two cases, yet come forward, and as the Library will be one of the most important adjuncts of the Society, and will be available to members both in and out of Calcutta, those who have not yet done so are invited to help the Society in making progress with this important branch of the work. Suggestions as to useful books for the Library will also be welcomed by the Librarian.

A number of books have already been received and can be borrowed by members in accordance with the Bye-Laws.

The books available can be ascertained from the Assistant Librarian and a catalogue will be issued shortly. The reading room of the Society in the Imperial Secretariat is now opened for the use of members daily from 5 to 7 p.m., except on Wednesdays and holidays, and from 3 to 5 p.m. on Saturdays, unless that day is a holiday.

The Journal.

The following charges have been fixed for back numbers of the JOURNAL :—

For members.—Per copy 12 annas ; per volume Rs. 5.

The Star Chart.—As. 12 a copy.

For non-members.—Rs. 1-8 per copy.

The Star Chart.—Rs. 2 a copy.

The Journal of the

Astronomical Society of India.

VOL. II.] SESSION 1911-1912. [NO. 9.

Report of the Meeting of the Society held on Tuesday, the 25th June 1912.

THE usual Monthly Meeting of the Astronomical Society of India was held on Tuesday, the 25th June 1912, at the Imperial Secretariat Buildings (Ground Floor).

H. G. TOMKINS, C.I.E., F.R.A.S., *President*, in the Chair.

S. C. GHOSH, M.A., *Officiating Secretary*.

The Minutes of the last meeting were read by the Secretary and confirmed.

The following presents to the Society were then announced and the thanks of the members accorded to the donors :—

Books presented by the President, Mr. H. G. Tomkins.

1. Monthly Notices of the Royal Astronomical Society—

Vol. LII.	Vol. LXVII.	Vol. LXIX.
Vol. LIV.	Vol. LXVIII.	Vol. LXX.

Publications received during June 1912—

1. Notices of the Royal Astronomical Society (Vol. LXXII, No. 6).
2. Journal of the British Astronomical Association (Vol. XXII, No. 7).
3. Memoirs of the British Astronomical Association (Vol. XIX, Part I).

4. Revista Di Astronomia (Anno VI, No. 5).
5. Monthly Weather Review of the Alipore Observatory for January 1912.
6. Journal of the Royal Astronomical Society of Canada (Vol. VI, No. 1).
7. The Collegian—

   Nos. 1 and 2, May 1912, and No. 1, June 1912.

The President then read the names of the following gentlemen elected at the last meeting and the elections were formally confirmed :—

1. D. QUINLAN, ESQ., M.R.C.V.S., Civil Veterinary Department, Ranchi Secretariat.
2. JYOTI PROSAD CHATTERJEE, ESQ., M.A., B.L., *Vakil*, Krishnagar.
3. MAHARAJA KSHAUNISH CHANDRA ROY of Krishnagar.

He invited those who had not signed the roll to do so.

The President.—As this is the last meeting of the Session, under Bye-Law 10 the Council have to present to the Society the proposed list for the election of the Council at the next meeting in October, and the list proposed by the Council is as follows :—

President ...	... W. J. SIMMONS, ESQ.
Vice-Presidents ...	... (1) COL. S. G. BURRARD, R.E., C.S.I., F.R.S.
	(2) J. EVERSHED, ESQ., F.R.A.S
	(3) C. MITCHIE-SMITH, ESQ., C.I.E., F.R.S.E., F.R.A.S.
	(4) HIS HIGHNESS THE MAHARAJA RANA BAHADUR SIR BHAWANI SINGH, K.C.S.I., F.R.A.S
Secretary (Scientific)	... DR. E. P. HARRISON, PH.D.
Do. (Business)	... C. V. RAMAN, ESQ., M.A.
Treasurer ...	... U. L. BANERJEE, ESQ., M.A.
Directors of Sections :—	
Lunar Section	... THE REV. J. MITCHELL, M.A.
Meteor Section	... P. C. BOSE, ESQ.
Variable Star Section	... B. M. RAKSHIT, ESQ., B.A.
Instrumental Director	... S. WOODHOUSE, ESQ.

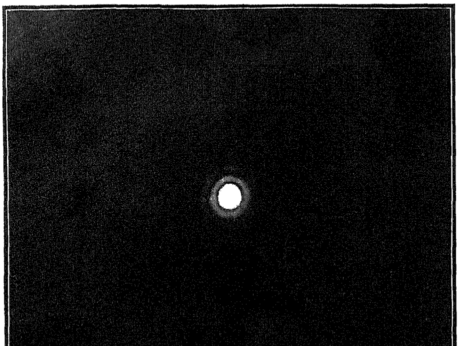


Fig. 1.

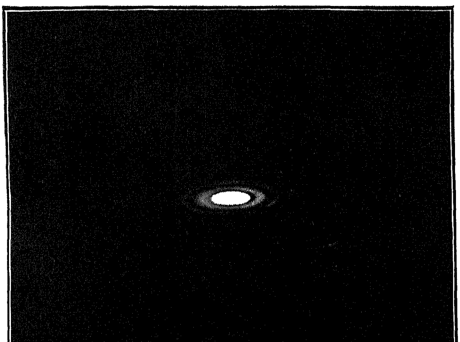


Fig. 2.

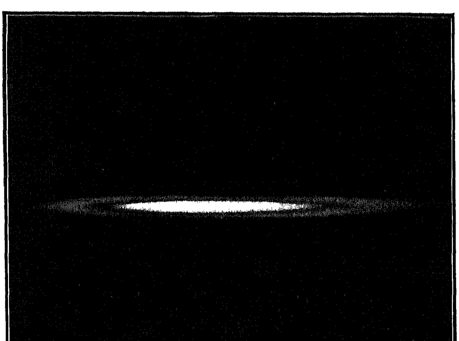


Fig. 3.

Fig. 4.

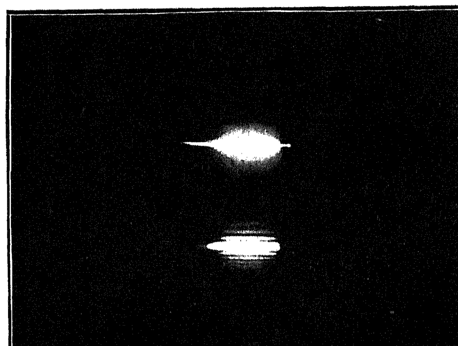


Fig. 5.

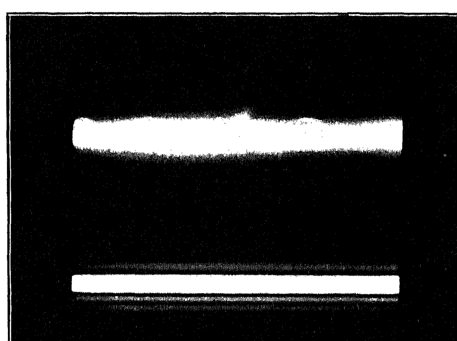


Fig. 6.

DIFFRACTION IMAGES.

Director of Classes	..	H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.
Secretary ...	...	P. C. BOSE, ESQ.
Librarian ...	...	J. A. LAWRIE, ESQ.
Editor ...	...	J. J. MEIKLE, ESQ.

Other Members of the Council.

J. C. DUTT, ESQ., M.A., B.L.
F. W. HOWSE, ESQ.
S. C. MITTER, ESQ., M.A., B.L
C. K. SIRCAR, ESQ., C.E., M.S.A., M.S.E.
D. N. MULLICK, ESQ., B.A., D.Sc.
D. N. DUTT, ESQ., M.A.
C. T. LETTON, ESQ.
MRS. TOMKINS.
C. W. PEAKE, ESQ., M.A.
W. A. LEE, ESQ., F.R.MET.S.

I have not heard from the gentlemen proposed that every one of them agree to serve, and the list is therefore subject to their agreeing to stand for election. I vacate the office of President at the end of this Session, under Bye-Law No. 5. Mr. Simmons has very kindly consented to be our President, and I think we are to be congratulated on his having agreed to stand for election to this office.

Should any of the members like to put in other names in the list they are free to do so. The next meeting will be held in October and at that meeting the election will take place.

I would now ask Mr. Raman to give us his paper on Astronomical Optics.

Mr. Raman then read his paper and illustrated it with lantern slides.

The President.—Mr. Raman has just promised to give us some account of the Zeeman effect later on. We learnt something about this sometime ago from Dr. Harrison, and I am sure we shall look forward to hearing more of it from Mr. Raman at a subsequent meeting. One point, which struck me, was that Mr. Raman says he had never stood on the platform when an Express passed by and noticed the changing tones of the whistle, but anyone who has stood there must have noticed this and how the pitch of the note alters as the engine approaches and then passes on. We must thank Mr. Raman for the valuable slides he has shown

us. They must have taken considerable trouble to make, for these things are not found in books or ordinary laboratories.

The thanks of the meeting were then accorded to Mr. Raman.

The President.—I will now ask Mr. Lee to read his paper on the Nebular Hypothesis and show us the slides regarding it.

Mr. Lee then read an interesting paper and showed a number of slides of Nebulæ at the end.

The President.—We are most fortunate this evening in having such an interesting paper, and should anyone like to ask questions, they may do so.

Mr. Simmons, in proposing a vote of thanks to Mr. Lee for his paper, said his reading it recalled to the speaker's mind the time in the early "nineties" when Mr. Lee used to take part in the proceedings of the now defunct Microscopical Society of Calcutta, and he was glad Mr. Lee had joined our Society. He agreed with Mr. Lee that whatever might be the difficulties raised by the Nebular Hypothesis, it was at present the best provisional theory of the solar system available. Evolution was now in the air, and everyone who thought at all was an evolutionist. Many still considered evolution applied only to organic nature. Laplace's theory with which Mr. Lee had been dealing showed that there had been evolution in inorganic nature. It raised difficulties, he believed they were chiefly mathematical. Mr. Hinks, to whose book the speaker had frequently directed attention at the meetings, said these mathematical difficulties were increasing year by year. There were, however, several features in the solar system which give support to the Hypothesis. The planets all revolved in one plane, they all revolved in one direction in their orbits, and in the same direction on their individual axes. With the outstanding cases of the satellites of Uranus and Neptune excepted, the satellites all revolved in the same direction. It was perhaps not without significance that Uranus and Neptune were the outermost planets of the system, and were followed by Saturn which still retained its rings. Ocular demonstration of the truth of the Nebular Hypothesis could not be expected ; a Nebular took very many millions of a year to condense. Nor did the Nebulæ which had so far been discovered furnish a complete series which would illustrate all the stages of the whole evolutionary process. But the Spiral Nebular was distinctly important and so too were the Nebulæ of a class illustrated by one of Mr. Lee's slides. It was an elegant form of Nebula, with marked condensation in the centre. That was in his opinion such a nebulous mass as the Hypothesis assumed, but seen edgeways.

For the present the speaker considered we must accept the Hypothesis as a working theory. It could be rejected when it had been further tested and proved to be insufficient.

There were many who scoffed at Science because it changed its theories from time to time. The speaker held it to be the glory of Science that it did change its hypothesis when they were tested and found wanting. Evolution, he would remind them, was not a new thing. It had been foreshadowed by Thales and Heraclitus. The Hindoos claimed it was also foreshadowed in the Sankhya Philosophy of Kapila, who evolved the Universe itself from emanations of a primeval essence.

The Nebular Hypothesis applied evolution to inorganic nature, and recently in experiments which showed that Radium was evolved from Uranium there was ground for considering that the very elements themselves were no more fixed entities than the stars themselves were fixed.

There was reason to believe there is what might be termed elemental evolution. It seemed to the speaker appropriate that at the close of a session during which planets and stars and stellar systems had been reviewed and discussed, they should have a paper on a subject which gave unity to all their speculations, and to the facts of Astronomical Science, and which suggested how the Universe itself had been evolved.

The President.—I will ask you to accord your thanks to Mr. Lee. One small item of business which comes under Bye-Law 27 has to be seen to this evening.

The October meeting will be the next Annual General Meeting. Some alterations have been proposed by Mr. Lee on behalf of the Council in Bye-Law No. 27.

"*Bye-Law No. 27.*—If the subscription be not paid within one month of the due date, a notice shall be given to the subscriber that he is in arrear. If the subscription be not paid within six months of the due date, the name of the subscriber shall be posted at the next meeting of the Society, and if the subscription be not paid within twelve months of the due date, the defaulter shall cease to be a member of the Society, unless otherwise ordered by the Council. The Council may at any time reinstate such a member upon payment of all arrears. For the purpose of this rule a notice shall be deemed to have been served if it is sent by registered post to the address of the member registered in the Society's books."

I am sorry to say that there have been certain members who have come as far as the 12 months limit and some the 6 months limit without paying their subscriptions. This compels the Society and Council to go through the unpleasant duty

of posting the gentlemen's names as men who have not paid their subscription at the next meeting. The Council think, however, that it is scarcely necessary to do this, though they find it absolutely necessary to protect the Society against members who will not pay their dues, but who nevertheless use the JOURNALS. There seems to be a kind of epidemic disease in India with regard to subscriptions which are neglected to be paid; but we cannot have JOURNALS and books sent to Members when they do not pay for them. We therefore propose the following amendment to the Bye-Law which I give notice will be considered at the General Meeting in October.

"*Revised Bye-Law No. 27.*—If a subscription be not paid within one month of the due date, a notice shall be given to the member that he is in arrear. If the subscription be not paid within five months of the due date the member shall be informed by a notice that if the subscription be not paid within six months of the due date the JOURNALS and other publications of the Society shall not be sent to the member until payment of the overdue subscription. If the subscription be not paid within twelve months of the due date, the defaulter shall cease to be a member of the Society, unless otherwise ordered by the Council. The Council may, at any time, reinstate such member upon payment of all arrears."

This is the last meeting of the Session, and during the next three months there will be no meetings at all. The library and business part of the Society, however, does not close and those who want to get books and JOURNALS may do so.

The meeting was then adjourned to 29th October 1912.

Astronomical Optics.

BY C. V. RAMAN, M.A.

Astronomical Optics is a very extensive subject, and this is not very surprising considering the fact that our principal source of information in Astronomy—one might almost say our only source of information, if we exclude the stray pieces of meteoric matter that occasionally reach the Earth's surface,—is the radiation that reaches us from the objects in the sky. I have therefore to confine myself to a few branches of my subject in the present paper. In the paper which I read at the last meeting of the Society I discussed the phenomena of

the "Diffraction of Light," and this leads me on to the application of the "Interference of Light" in Astronomical work. In fact the two subjects are very closely related to each other : it will be remembered that I explained Diffraction in my previous paper as the result of the interference of the effects of the very large number of light-sources into which we may conceive a light wave of limited extent to be split up.

Every reader of this JOURNAL can see for himself the bright and dark fringes due to the interference of two light sources with the simplest of apparatus. All that is required is an ordinary undeveloped photographic plate—quarter-plate size is very convenient. With a needle, two fine lines parallel and pretty close to each other should be ruled on the film, so that the light shows through the lines. On viewing the filament of an ordinary electric light or the edge of the flat flame of a paraffin lamp from a distance through the plate with the two lines close to the eye and parallel to the source of light, the fringes will be recognized at once. They are generally very sharp and clear, and the distances between the successive dark and bright bands are all equal. It will be found on trial that with the two slits wide apart the fringes are narrow and *vice versâ.* In fact the width of the fringes is inversely proportional to the distance between the two slits.

It is very instructive to compare the interference fringes due to two narrow slits held at a distance apart with the diffraction bands due to a single wide aperture. The differences are very marked. In the latter case, the central bright band is twice as broad as any of the bright bands on either side of it, and the central band is much brighter, in fact about 20 times as bright as the first order bands on each side of it. The result of this rapid falling off in intensity is that with a feeble source of light it is hardly possible to fix the position of the first dark bands on either side with much precision and in Astronomical work, the boiling of the image due to atmospheric disturbances renders this more difficult still. With interference fringes on the other hand we have equally spaced bands and the central band does not differ very appreciably in brightness from the bands on either side of it, provided that the width of each of the two slits is very narrow compared with their distance apart. The theory of the formation of these interference fringes has been sufficiently explained by me in my previous paper.

We now proceed to consider Michelson's application of interference fringes to the problem of the measurement of the angular diameters of planetary (or stellar) objects. It is well-known that micrometric measurements made by the best

observers with the largest telescopes of objects like the satellites of Jupiter differ very largely (by 30 or 40 per cent.) amongst each other. The reason for this uncertainty is principally the broadening and diffusion of the image by diffraction and its disturbance by atmospheric causes. Hence the interest of Michelson's method, the theory of which is in its essentials fairly simple.

The simple apparatus which I described above comes in very useful here. If, instead of observing the narrow edge of the flame of a lamp through the pair of slits, the flame is viewed broadside on, the interference fringes will be found to be no longer visible. The explanation of this is that the different parts of the source produce each its own set of interference fringes. These are not "in register" so to say and their superposition results in the production of uniform illumination over the field. If the object-glass of a telescope had a cover put on with two narrow parallel slits cut in it at some distance apart from each other and a bright star were observed through the telescope, we would see in the field of view a narrow strip of light crossed by fine interference fringes. If, instead of a star, a planet were observed, the interference fringes would probably be no longer visible, the cause of their disappearance being the superposition of the interference fringes due to the different parts of the source. It is evident that the extent of the confusion depends on the angular diameter of the object viewed, and on the angular width of the interference fringes in the field. If the slits on the cover of the object-glass were gradually drawn apart, the fringes would gradually decrease in width and at a certain stage would become obliterated. The distance apart of the slits at which the fringes first cease to be visible gives us a measure of the size of the object viewed.

If, instead of being a disc of finite size, the object was a double star, the change in the visibility of the fringes as the distance between the slits is increased can be very readily calculated. If the angular separation of the double star (say θ) were equal to $\lambda/2a$ (λ being the wave-length and a the distance between the two slits), it is clear that the bright bands in the fringes due to one of the stars in the double would coincide with the dark bands of the other set, and the fringes would have just disappeared. When a the distance between the slits is further increased, so that $\theta = \lambda/a$ the fringes would re-appear with practically their full original intensity since the bright bands of one set coincide with the bright bands of the other set and *not* with the dark bands. In fact as a is gradually increased the fringes pass through alternate cycles of visibility

and invisibility. With a disc of finite size instead of a double star as the object, the interference fringes do not regain their full degree of visibility when a is increased beyond the value at which they first disappeared. There should, however, be a very appreciable re-appearance.

This phenomenon of the restoration of the visibility of the fringes after their initial disappearance with a source of finite size is one of considerable interest, and I was at some pains to verify it experimentally with simple apparatus. In fact, I had no arrangement at my disposal by which the distance apart of the two slits could be gradually increased. A little consideration will show, however, that precisely a similar effect should be obtained by having the two slits at a constant distance apart and gradually increasing the size of the source. A single slit with adjustable jaws held against a window gives us a source whose size can be varied at will, and this is used instead of the paraffin lamp or the incandescent filament in the experiment previously described. As the width of the source is gradually increased, the initial disappearance, then the partial restoration, the second disappearance, etc., of the fringes can all be observed.

The value of the interference method is shown by the fact that working with slits only four inches apart on the object-glass of a telescope, Michelson obtained measurements of the diameter of the four principal satellites of Jupiter which were far less uncertain than the best measurements made by the micrometric method with the 40-inch glass at Yerkes.

I now proceed to consider another very important and interesting phenomenon, the Doppler effect. This refers to the change in the wave-length of radiations that is detected spectroscopically when the source and the observer are in motion relatively to each other along the line, joining them. The cause of this change in wave-length is not very difficult to understand. When the source and observer are in relative motion towards each other, each successive wave emitted by the source has a shorter distance to travel before it reaches the observer than it would otherwise have to do and therefore arrives sooner. The frequency of the disturbance as it passes the observer is therefore increased and the wave-length diminished. The spectrum lines are therefore shifted towards the violet. The reverse is true when the source is moving away from the observer in the line of sight. An interesting acoustic analogy is furnished by a whistling locomotive as it passes the observer standing by, or situated in a train moving in the opposite direction, a sudden flattening of the note being very appreciable,

as the text-books say. Curiously enough I have no recollection of having noticed this phenomenon, probably I never paid any attention to it when on the rail-road.

Doppler's principle has had many and wide applications in astronomical and astrophysical work. Probably the most recent is the spectroscopic discovery of the rotation of Uranus. It is evident that if the planet is rotating, one limb of it should be moving towards the observer in the line of sight and the opposite limb away from the observer. If the slit of the spectroscope were set upon the image of the planet, the wave-length of the light from the two ends of the slit would be altered in opposite directions, and we would as the result have the lines crossing the spectrum at an *inclination* instead of perpendicularly. This was actually observed.

Double stars have been discovered by the Doppler effect, the components of which no telescope will show separated, and their time of revolution about their common centre of gravity determined. Such stars are called spectroscopic binaries. The first was discovered at the Harvard Observatory by Pickering. Observation of a number of spectra of this star taken at different times showed that the lines became double at stated intervals, an effect which could only be explained by assuming the source of light to consist of two bodies which alternately approached and receded, in other words two bodies rotating about their common centre of gravity. If we photograph the spectrum of a double star one of the components of which is a dark body, side by side with a comparison spectrum at various times, the spectrum lines are seen single, but then appear to change their position periodically. In other words the velocity of the bright component in the line of sight varies with its position in the orbit.

A large number of other applications of Doppler's principle could be mentioned, but undoubtedly the most important is the general investigation of the line of sight motions of the stars which coupled with the determination of proper motions (*i.e.*. motion at right angles to the line of sight) must in time furnish us with the key to the solution of that greatest problem of astronomy, the nature of motion of the multitude of suns which make up the Universe. As the fruit of investigations on this subject we have Kapetyn's two-stream theory of the Universe and so on. Professor Turner suggests in recent articles that these 'streams' are in reality the results of the gravitation of the Universe towards the centre of its systems.

It has been found possible to verify Doppler's principles experimentally in the case of light. The minimum velocity capable of modifying the wave-length to such a degree that

the spectroscope will note the change is about half a mile per second. To obtain a source of light moving with such a tremendous velocity inside a laboratory, the only practicable plan appears to be to make use of multiple reflections from systems of mirrors mounted on the rims of rapidly revolving wheels. For the velocities used, the change of wave-length on reflexion from a normally moving mirror is identical with that due to a motion of a source with double its velocity, and the effect would evidently be augmented by multiple reflexion, the alternate sets of mirrors (mounted on the rim of moving wheels) being rotated in opposite directions. After such repeated reflexions the light is analysed by a powerful spectroscope which reveals the change of wave-length.

To Stark is due the brilliant discovery of a second method by which the Doppler effect may be demonstrated in the laboratory, and this was the employment of the Canal rays due to the electric discharge in a vacuum tube. These Canal rays are supposed to be positively charged gaseous particles which are shot down the tube with a tremendous velocity (a few hundreds of miles per second) and may be isolated by using a perforated Cathode through which the rays emerge into the space beyond. The light emitted by these particles in the direction of their motion when analysed by a spectroscope shows the Doppler effect in a remarkably striking way. As the exhaustion of the tube proceeds, a wing appears to split off from the spectrum lines and gradually moves towards the violet sides of the spectrum. The detached line is somewhat broad and diffuse on account of the differences in the velocities of the different particles. There is always a line present also in the original position, showing that some of the particles emitting the light do not share in the motion of the Cathode rays.

The Nebular Hypothesis.

By W. A. Lee.

The oldest views of the Universe represented the hosts of heaven as persons who had lived on Earth. This idea seems to have been widely held in Europe, in Asia, and by Negroes in Central Africa. Beliefs are gradually modified, they are subject to the universal law of evolution, and accordingly ideas as to the personality of celestial bodies gradually changed until in the Middle Ages it was generally believed that the planets

were directed in their orbits by Spirits or Gods Later it was shown that gravitation sufficiently explained and accounted for the movements of planets in their orbits, and the old belief had to be further modified, and the God or Spirit holding each planet in its orbid was abandoned, and for this belief was substituted the theory that each planet was separately made and started off in its appointed orbit by an omnipotent Creator. Within the last 200 years this speculation as to creative methods has been gradually replaced by a finer conception.

In the middle of the eighteenth century a Mr. Thomas Wright, a mathematical instrument maker in Fleet Street, wrote a book called "A New Hypothesis of the Universe," in which he suggested that the stars formed a regular system, an idea not previously published. He believed that the Sun is a member of the group of stars forming the milky-way and that the milky-way is one of many systems of stars, and that other galaxies form with the milky-way a system of stars. He suggested that the nebulæ are other galaxies.

In 1755 Emanuel Kant published "The Natural History of the Heavens" based upon Wright's work, and he proceeded to argue from Wright's hypothesis of the structure of the Universe that such systems as the solar system might have originated from the condensation of a nebula. He was puzzled to account for uniform planetary motion, and he tried to prove, what we now know to be impossible, that the interaction of its particles could set up a vertical swirl in the nebula. Kant supposed the centre of a nebula to be an aggregation of atoms which gradually grew by the falling upon it, under the action of gravity, of further atoms. He thought that the particles in falling together by gravity were unable to fall directly towards the centre because of collisions with other particles, and from these collisions indefinitely multiplied he believed a swirl or rotation would result.

Kant thought that the planets originated through the formation of other and smaller nuclei in the original nebula. His mental vision saw a principal nucleus in the original nebula and a number of lesser nuclei, and he thought the Sun originated through the growth and accretion of the largest nucleus, and the planets and their moons through the growth of the smaller nuclei. It was in accounting for the movements of the planets that Kant's theory broke down. As each planet was separately formed and its rotation separately determined by the interaction of the particles falling together during its formation, the rotation would be as likely to be retrograde as to be direct, as likely to be in one plane as another, and the

uniformity of direction of movement in the solar system puts out of court a theory of origin which assigns an independent fortuitous origin for such a number of similar movements.

At the end of the eighteenth century Laplace published his hypothesis. He assumed the existence of an extended nebula of great tenuity, but at a high temperature, and with an initial swirl or rotatory movement. Laplace endeavoured to demonstrate the probability that the nebula in cooling contracted, and in contracting accelerated its movement of rotation. This continual acceleration of rotation proceeded until the centrifugal force was equal to the attraction of gravitation and caused separation of a portion of the equatorial region of the rotating mass, in the form of a ring. The ring so thrown off would continue to rotate at the speed of rotation of the mass at the time the ring was thrown off, and would gradually coalesce into a planetary globe, and the successive throwing off of such rings, as the great nebula contracted, would form a succession of planets. The planetary nebulæ as they cooled and contracted would similarly throw off rings which would form subsidiary globes of satellites. Laplace worked out his hypothesis in great detail, and endeavoured to account for all the observed phenomena in the solar system. The very precision of his theory made it vulnerable, and objections and difficulties had more destructive force than they would have had on a more vague theory. The Nebular Hypothesis took such a hold of the scientific imagination of astronomers that it has persisted for a century and a half in spite of criticisms that in their time have appeared destructive. This has been partly due to the fact that the hypothesis has also from time to time received support by discoveries and theories of later date.

One of the earliest difficulties arose by the discovery of the retrograde systems of Uranus and Neptune, whose satellites revolve round their respective primaries in the reverse direction to the moons of all the other planets. It was eventually pointed out, however, that if the contracting nebula threw off nebulous matter in the form of a ring it would depend on the shape of the ring whether the direction of movement is direct or retrograde.

Then the Nebular Hypothesis obtained support, as strong as it was unexpected, from the discovery of the conservation of energy and its application to celestial phenomena. Laplace had postulated a primordial nebula extremely tenuous, but he had to assume that his nebula was already extremely hot. This was a great demand upon the imagination, and when it was shown that the action of gravity under which the nebula

was assumed to contract would be accompanied by a continuous evolution of heat, the Nebular Hypothesis acquired a new importance, and the demonstrated fact that energy is indesitructible lent support to the hypothesis just where support was badly wanted.

Another difficulty arose from Lap lace's dictum that as each planetary ring of matter was thrown off by the original nebula it would continue to revolve round the central nebula at the speed, and in the period at or in which the surface of the nebula rotated at the moment of separation : that is to say, that the Sun which now rotates in little less than a month would have rotated in a year when it filled the Earth's orbit, at the time when the ring of nebulous matter which was to form the Earth had just been separated.

The energy of rotation of the Sun must have been the same in all ages, the moment of momentum is invariable, time neither adds to it nor can time take anything from it, and therefore it is a matter of simple calculation to see what the period of rotation of the Sun would be if it were swelled up in size to the dimensions of the Earth's orbit. It would rotate not in one year but in 3,000 years. This means that at the time when the nebulous Sun was separating off the ring of nebulous matter which was to form the Earth, not only was the Sun not rotating in one year, but it was not rotating fast enough to throw off a ring of matter; it was rotating so slowly that the force of gravity was not overcome by the centrifugal force.

Similarly if you imagine the Sun expanded to the size of the orbit of Neptune its rotation period must have been thousands of centuries—far too slow to throw off any of its substance and so form planets.

The Nebular Hypothesis, indeed, requires that the contracting Sun shall rotate all the time at such a speed that it is in a state approaching unstable equilibrium, and the centrifugal effect of rotation is only just counterbalanced by the action of gravitation. It would require that the Sun should be now rotating at such a speed that its equatorial particles are only just held together by gravity. I need hardly say that this is not the case : it would require the Sun to rotate, not in a little under a month as it does, but in less than an hour.

The Nebular Hypothesis, as stated by Laplace, requires the contracting nebula to rotate more and more rapidly as it contracts. This is also shown to be a necessity by the theory of the conservation of energy ; it follows that each planet, after having thrown off a satellite, as it goes on contracting rotates more rapidly than it did at the time when the satellite was

formed. Now, according to the Nebular Hypothesis, the satellite revolves round its primary in the period in which the primary rotated at the time the satellite was formed. Therefore the contracted primary must rotate at a more rapid rate than that at which the satellite revolves round it. This is observed almost throughout the solar system, but there are at least two, perhaps three, instances of the contrary. The inner satellite of Mars ievolves round is primary in one-third of the period of rotation of Mars, and Saturn's inner ring revolves in half the time the planet rotates. These are discrepancies that have not been explained, and which are difficult to meet.

Another criticism has lately arisen based upon the modern view of the mechanism of a gas.

The molecules of a gas are in continuous and rapid movement, and this would cause, it is alleged, a continuous loss of the constituents of a gas expanded to the extent assumed for the primordial nebula. The lighter gases, those whose molecules are the most active, would naturally be the first to leak away into space, and in this way all the hydrogen would be lost, and then helium and other gases in proportion to their lightness.

But all the hydrogen and helium has not disappeared from the solar system ; both are present in enormous quantities, in very large proportions, in the Sun.

As far as we feel at liberty to apply knowledge gained on Earth of the materials of which the solar system is composed, we are able to say that the Sun in radiating heat into space is cooling, that in cooling it is contracting and that its contraction is accompanied by the evolution of heat. The limit of the heat which the sun can radiate is therefore limited by its contraction, and when it can contract no more it can only radiate the quantity of heat that it then happens to contain. We can therefore oresee a time when the radiation of the Sun will cease, and it will be dead and cold, and we can calculate more or less approximately when this will be.

Applying the same reasoning in the other direction we believe that at one time the Sun was larger than it is now. Perhaps the preglacial men, a quarter of a million years ago, if they had been armed with instruments of precision could have measured the face of the Sun as being perceptibly larger. We believe that in the ages represented by the time of deposition of the sedimentary rocks the Sun has shrunk considerably and that it was a distinctly larger Sun that shone on the world when our coal mea ures were being formed. Thinking back further we see the Sun expanded to the size of the Earth's

orbit, before that to fill the orbit of Jupiter, earlier it filled the orbit of Saturn, still earlier that of Neptune. There seems no escape from this. In the present state of our knowledge it is unavoidable.

Then if the present conditions make it appear that the Sun has contracted from a nebula having a diameter as great as the orbit of Neptune, and when we see the uniformity of the movements of the planets and the Sun, we are naturally attracted to the belief, no matter what its difficulties, that the planets were somehow formed during the contraction of the Sun from a great nebula engulfing the whole of the solar system, although it is questionable how far the present uniformity of movement can be regarded as proof of original uniformity.

Extracts from Publications.

A Simple Eclipse Experiment.—The phenomena of an eclipse may be well reproduced by a simple experiment made as follows :—

Make a smooth round hole, about one-eighth of an inch in diameter, in a visiting card or thin sheet of metal, and allow the rays from the Sun or other source of light to pass through the hole and fall on a sheet of white paper held parallel to the card, and at right angles to the rays. Take a pin with a round head of black glass, of a diameter very little less than the hole in the card, and holding it about an inch from the card, pass it very slowly across the hole. The bright image of the Sun will then pass through all the stages of an eclipse, commencing with the "first contact" as the head of the pin first emerges into the rays at the edge of the circular disc of light, and forming all the successive crescent phases until it lies co-axially with the hole in the card, when the appearance of an "annular eclipse" is reproduced. Further movement of the pin in the same direction will reproduce the phases which occur after totality has been reached, giving, finally, the phase of "last contact."

If the bright annular ring of light be examined carefully, when the eclipse is at its maximum, it will be seen to be free of blurs or blemishes if the edges of the hole and the head of the pin are both clean and free from projecting particles. Now coat the head of the pin with fine dust, such as flour or

the pollen of a flower—even fine tobacco ash will suffice—and repeat all the above operations. No roughness, or only a very little, will be seen on the dark image of the "Moon"—the pin's head—until the annular stage is reached, when quite suddenly there will appear black spots and streaks in the bright ring of light, giving one the impression that "Baily's beads" have been produced. Whatever may be the true cause of the latter phenomenon during an annular eclipse of the Sun, such as was witnessed on April 17th last at some places, the effect in the experiment above cited may be produced in one of three ways; first by roughening the surface of pin's head; secondly, by dust on the edges of the hole; thirdly, by both the causes stated in the first and second cases acting simultaneously.—W. G. ROYAL-DAWSON.

[*The Mechanic.*

A simple method of correcting the Sun's declination for refraction.—In "Field Manual of Engineering Instruments" by Professor L. S. Smith is described a method of making the above correction, which requires, in addition to a transit theodolite, nothing except a watch with a second-hand, dispensing entirely with the use of tables.

Having focussed the eye-piece and object-glass of the theodolite so that a clear image of both the Sun's disc and the cross-wires can be seen on a piece of white paper held behind the eye-piece, set the horizontal circle of the theodolite to read some integral ten minutes and point on the Sun by the lower motion.

The Earth's diurnal motion will carry the Sun across the vertical wire of the instrument. Note the time to the nearest second when the Sun is tangent to the vertical wire. Keeping the lower plate clamped, unclamp the upper and turn the telescope in the direction of the Sun's movement—*i. e.*, towards the West and set the Vernier to read the next ten minutes. Note again the time when the Sun is tangent to the vertical wire. Also read the vertical angle to the Sun. Then if we call n the interval of time elapsed in seconds, while the Sun (really the Earth) was passing through ten minutes of arc, and call h the vertical angle in degrees, the refraction d (in minutes) is given by the equation :—$d = 2{,}000/h \times n$.

Experience in using this formula has shown that its maximum errors will not exceed 15″ when the Sun is above 10° altitude, while its average error is less than half this amount. As the refraction correction, as ordinarily computed, is based upon average conditions of temperature and barometric pressure, seldom exactly realised in any given case, the author has

not been surprised to find that results obtained by the use of the above formula are quite as good as those obtained from the more complicated and portentous formulæ and tables.

A still more accurate determination of the refraction can be made by the use of the following equation :—$d = 100 \times \frac{N}{n}$ where d and n stand for the same quantities as before, and N is obtained from the following table by entering it with the measured altitude of the Sun as an argument :—

H	N	Diff. for 1°	H	N	Diff. for 1°
10°	.. 131	.. 9	30°	.. 36	1·4
15	.. 86		40	.. 22	
20	.. 62	.. 5	50	.. 13	.. 0·9
25	.. 47	.. 3	60	.. 7	.. 0·6
30	.. 36	.. 2	70	.. 3	.. 0·4

The altitude of the Sun need only be observed to the nearest half-degree.

The tabulated values of N correspond to a temperature of 50° F., and a barometric pressure of 30″. They may be adopted to any other temperature by diminishing d by one per cent. for each 5 degrees by which the temperature exceeds 50° or by increasing one per cent. for each 5° below 50°.

This correction and the correction for variations of the barometer can usually be neglected. At great elevations, however, the barometric pressure becomes so much reduced that its variation must be taken account of, and this is done by diminishing d by one per cent. for each 300 feet of elevation above the sea.—COSMO.

[*The Mechanic.*

The Speciroscopic Discovery of the Rotation Period of Uranus.—The primary work of the Lowell Observatory is the study of the planets of our solar system, their present state, and, from that the principles of their evolutionary careers—a subject I have ventured to call planetology. In this one planet is as important as another, since each represents a stage in development through which, more or less, all must pass. Popular interest is largely limited to Mars, for self-evident reasons of affinity ; not so ours. Personally, I must disclaim a certain philanthropy with which I have been credited and which I do not possess—the desire to people the orbs about us. No such incentive is mine, but the broader one to learn what is.

Of the planets, the latest to contribute something new to this our search is Uranus, and this on a matter which has long been a desideratum and has largely remained obstinately hid— the rotation period of his spin. It was wanted because it was the only one of his bodily elements about which we knew practically nothing and a knowledge of which was essential in the problem of his density distribution. The blankness of expression of his face seemed to preclude any visible insight into his movements, and the direction of his axial tilt negatived spectroscopic determination. For ever, since the spectroscope became capable of putting the question, his south pole has been turned toward us in a way to render relative approach or recession of his surface sensibly nil.

For some years, one of my assistants, Dr. V. M. Silpher, had been trying in vain to get it, had recognised its then unfeasibility, and temporarily dropped it, when the thought of a certain trigonometric relation induced me to hope that perhaps success might now follow. This relation was the fact that the cosine of an angle changing from 90° to 0° increases much faster than the angle itself during the early stages, and that therefore, through the Uranian pole had only got half-way in its course toward righting, its cosine had reached seven-tenths of its full amount, and the cosine, not the angle, enters into the velocity equation.

The event justified the supposition. In August 1911 Dr. Silpher attacked the planet again with apparatus which he had himself improved for the problem and secured eight spectrograms. As a check upon possible error, half of the number were taken with the spectroscope to the east of the telescope-tube, half with it to the west. Other experiments proved flexure to have been eradicated. The spectroscope was attached to the 24-inch objective, and the exposures made as near the meridian culmination as possible considering their length.

The slit was placed parallel to the longer axis of the satellites' apparent orbits. This was done in accordance with the only hint we have of the planets' equatorial plane. The inference seems justified by the behaviour of the satellites of Jupiter and of Saturn. For the orbital planes of these satellites approach coincidence with the equatorial plane of their primaries in proportion as the satellites themselves stand near, the only exceptions to this general law being those of tiny mass. The probable explanation of this is that the planets originally revolved retrogradely and are now in process of righting, carrying their satellites over with them, their power to do so being more instant on the nearer ones. The fact and

its explanation I have pointed out in my "Solar System" and "Evolution of Worlds."

In the spectrograms the spectrum of Uranus lies enclosed between two comparison spectra, taken the one before the other after the Uranus exposure. Were the planet not rotating, the lines in the three spectra would be theoretically parallel, practically affected by a slight general curvature. In consequence of any rotation the approaching edge of the planetory lines is shifted toward the violet, the receding toward the red, with the result of tilting the Uranian lines with regard to their flanking comparison counterparts. Positives of two of these spectrograms are here exhibited, enlarged so that they may be examined by any one without the use of a microscope or measuring machine. The one was taken with the camera to the east, the other with it to the west of the telescope itself. The tilt of the Uranian lines is evident in each, and the opposite sense of them in the two, the lines being tilted upon the right in the one, on the left in the other, the red end of the spectrum being at the bottom of the plate in both cases. Furthermore, with care the greater inclination of the lines toward the violet end may be detected, which, of course, should be the case.

In examining them, the consensus of all should be considered, because any particular one may be injuriously affected by the grain of the plate. One of the grains may be larger and more darkened than another, and as the size of the grains bears an appreciable ratio to the size of the lines, the result is to shift the apparent direction of the line itself. By considering many we eliminate this source of error. The effect of the grain in deforming or masking original linearity has an important application for those who would examine delicate planetory photographs. It is the integrated, not the disintegrated, appearance which reveals the reality, as these Uranus plates themselves point out. For their spectroscopic lines, which show anything but regular, are, we know, the plates' representations of a slit as linear and geometric as man can make. This granular defect, which superior visual observation rectifies in the one case, also rectifies in the other.

The great care which Dr. Silpher gave to avoid error in the taking of the spectrograms, he no less took in measuring them. To show with what accuracy his plates were made, measures of the comparison lines may easily be relied on to within 3″ of arc. I speak from memory, and it may be less. The Uranian lines are much more difficult. His measures, however, are conclusive and are borne out by my own,

though I am far from ascribing to mine the value I could wish with more time.

The result of both gives for the rotation period of Uranus $10\frac{3}{4}$ hours in a retrograde direction.—PERCIVAL LOWELL.

[*The Observatory.*

Memoranda for Observers.

Standard Time of India is adopted in these Memoranda.

For the month of August 1912.

Sidereal time at 8 p.m.

			H.	M.	S.
August 1st	..	..	.. 16	39	19
,, *8th*	..	..	.. 17	6	55
,, *15th*	..	..	.. 17	34	30
,, *22nd*	..	..	.. 18	2	6
,, *29th*	..	..	.. 18	29	42

From this table the constellations visible during the evenings of August can be ascertained by a reference to their position as given in the Star Chart.

Phases of the Moon.

				H.	M.
August 6th	Last Quarter	..	..	9	48 A.M.
,, *13th*	New Moon	..	..	1	28 A.M.
,, *19th*	First Quarter	..	..	10	27 P.M.
,, *28th*	Full Moon	..	..	1	29 A.M.

Meteors.

	R. A.	Dec.	Character.
July—September	335°	+73°	Swift, short.
July—August	339	—27	Slow, long.
July—August	280	+57	Slow, short.
August 10th—12th The Perseid shower	45	+57	Swift, streaks.
August 15th	290	+53	Swift, bright.
,, *15th—25th*	291	+60	Slow, bright.
,, *25th*	5	+11	Slow, short.
August—October 2nd.	346	0	Slow.
,, ,,	74	+42	Swift, streaks.

Planets.

Venus—Is an evening star. The position of this planet on the 15th August at 8 P.M. will be R. A. 10 h. 23 m. 57 s. Dec 11°-33′-52″ N. The time of its setting on the 15th August will be 6 h. 47 m. P.M.

Saturn.—The position of this planet on the 15th August at 8 P.M. will be R. A. 4 h. 6 m. 22 s. Dec. 18°-48′-50″ N. The time of its rising on the 15th August will be 11 h. 31 m. P.M.

Mars.—The position of this planet on the 15th August at 8 P.M. will be R. A. 11 h. 18 m. 47 s. Dec. 5°-22′-16″ N. The time of its setting on the 15th August will be 7 h. 32 m. P.M.

Jupiter.—The position of this planet on the 15th August at 8 P.M. will be R. A. 16 h. 16 m. 2 s. Dec. 20°-44′-58″ S. The time of its setting on the 15th August will be 11 h. 44 m. P.M.

For the month of September 1912.

Sidereal time at 8 p.m.

	H.	M.	S.
September 1st	18	41	32
,, *8th*	19	9	8
,, *15th*	19	36	44
,, *22nd*	20	4	20
,, *29th*	20	31	55

From this table the constellations visible during the evenings of September can be ascertained by a reference to their position as given in the Star Chart.

Phases of the Moon.

			H.	M.	
September	*4th*	Last Quarter	6	53	P.M.
,,	*11th*	New Moon	9	19	A.M.
,,	*18th*	First Quarter	1	25	P.M.
,,	*26th*	Full Moon	5	4	P.M.

Meteors.

		R. A.	Dec.	Character.
July—September		335°	+73°	Swift, short.
September	*3rd—8th*	353	+39	Very swift.
,,	*5th—15th*	62	+36	Swift, streaks.
,,	*6th—17th*	106	+52	Swift, streaks.
,,	*15th*	77	+57	Swift, streaks.
,,	*21st*	31	+19	Slow, trains.
,,	*21st—27th*	87	+43	Swift, streaks.
,,	*27th*	4	+28	Slow, trains.
August—October 2nd		346	0	Slow.
,,	,,	74	+42	Swift, streaks.

Planets.

Venus—Is an evening star. The position of this planet on the 15th September at 8 P.M. will be R. A. 12 h. 44 m. 52 s. Dec. 3°-49′-28″ S. The time of its setting on the 15th September will be 6 h. 40 m. P.M.

Saturn.—The position of this planet on the 15th September at 8 P.M. will be R. A. 4 h. 10 m. 9 s. Dec. 18°-53′-41″ N. The time of its rising on the 15th September will be 9 h. 33 m. P.M.

Mars.—The position of this planet on the 15th September at 8 P.M. will be R. A. 12 h. 31 m. 41 s. Dec. 2°-46′-23″ S. The time of its setting on the 15th September will be 6 h. 29 m. P.M.

Jupiter.—The position of this planet on the 15th September at 8 P.M. will be R. A. 16 h. 26 m. 47 s. Dec. 21°-16′-20″ S. The time of its setting on the 15th September will be 9 h. 52 m. P.M.

For the month of October 1912.

Sidereal time at 8 p.m.

	H.	M.	S.
October 1st	20	39	49
,, *8th*	21	7	24
,, *15th*	21	35	0
,, *22nd*	22	2	36
,, *29th*	22	30	12

From this table the constellations visible during the evenings of October can be ascertained by a reference to their position as given in the Star Chart.

Phases of the Moon.

		H.	M.	
October 4th	Last Quarter	2	18	A.M.
,, *10th*	New Moon	7	11	P.M.
,, *18th*	First Quarter	7	36	A.M.
,, *26th*	Full Moon	8	1	A.M.

Meteors.

	R. A.	Dec.	Character.
October 2nd	230°	+52°	Slow, bright.
,, *4th*	310	+79	Slow.
,, *8th*	77	+31	Swift, streaks.
,, *8th—14th*	45	+58	Small, short.
,, *14th*	133	+68	Rather swift.
,, *15th*	31	+ 9	Slow.
,, *18th—20th* (Important).	92	+15	Swift, streaks.
,, *23rd*	100	+13	Swift, streaks.
,, *29th*	109	+23	Very swift.

Planets.

Venus—Is an evening star. The position of this planet on the 15th October at 8 P.M. will be R. A. 15 h. 4 m. 54 s. Dec. 17°-44′-15″ S. The time of its setting on the 15th October will be 6 h. 38 m. P.M.

Saturn.—The position of this planet on the 15th October at 8 P.M. will be R. A. 4 h. 7 m. 4 s. Dec. 18°-40′-57″ N. The time of its rising on the 15th October will be 7 h. 32 m. P.M.

Mars.—The position of this planet on the 15th October at 8 P.M. will be R. A. 13 h. 45 m. 38 s. Dec. 10°-34′-23″ S. The time of its setting on the 15th October will be 5 h. 32 m. P.M.

Jupiter.—The position of this planet on the 15th October at 8 P.M. will be R. A. 16 h. 46 m. 16 s. Dec. 22°-0′-1″ S. The time of its setting on the 15th October will be 8 h. 12 m. P.M.

For the month of November 1912.

Sidereal time at 8 p.m.

		H.	M.	S.
November	*1st*	22	42	2
,,	*8th*	23	9	38
,,	*15th*	23	37	14
,,	*22nd*	0	4	49
,,	*29th*	0	32	25

From this table the constellations visible during the evenings of November can be ascertained by a reference to their position as given in the Star Chart.

Phases of the Moon.

			H.	M.	
November	*2nd*	Last Quarter	9	8	A.M.
,,	*9th*	New Moon	7	35	A.M.
,,	*17th*	First Quarter	4	13	A.M.
,,	*24th*	Full Moon	9	42	P.M.

Meteors.

		R. A.	Dec.	Character.
November	*1st*	43°	+22°	Slow, bright.
,,	*2nd*	58	+ 9	Slow, bright.
,,	*5th to December 4th.*	162	+58	Swift, streaks.
,,	*10th—12th.*	133	+31	Very swift, streaks.
,,	*14th—16th.*	150	+22	Swift, streaks.

		R. A.	Dec.	Character.
November	*16th—28th.*	154	+41	Swift, streaks.
,,	*20th—23rd.*	63	+23	Slow, bright.
,,	*17th—23rd.*	25	+43	Very slow, trains.
,,	*25th to December 12th.*	189	+73	Rather swift.
,,	*30th*	190	+58	Swift, streaks.

The showers on the 14th to 16th and 17th to 23rd are celebrated Leonid and Andromedid Meteor showers respectively.

Planets.

Venus—Is an evening star. The position of this planet on the 15th November at 8 P.M. will be R. A. 17 h. 45 m. 55 s. Dec. 25°-4′-19″ S. The time of its setting on the 15th November will be 7 h. 2 m. P.M.

Saturn.—The position of this planet on the 15th November at 8 P.M. will be R. A. 3 h. 58 m. 20 s. Dec. 18°-14′-47″ N. The time of its rising on the 15th November will be 5 h. 23 m. P.M.

Mars.—The position of this planet on the 15th November at 8 P.M. will be R. A. 15 h. 8 m. 41 s. Dec. 17°-37′-19″ S. The time of its rising will be 5 h. 35 m. A.M. on the 16th November.

Jupiter.—The position of this planet on the 15th November at 8 P.M. will be R. A. 17 h. 12 m. 50 s. Dec. 22°-42′-21″ S. The time of its setting on the 15th November will be 6 h. 35 m. P.M.

Notices of the Society.

Election of Members.

The attention of members is invited to Bye-Law No. 14, regulating the election of persons who desire to join the Society. It is hoped that those who are already members will induce others to join. Forms of application can be had from the Secretary.

Change of Addresses.

It is particularly requested that when members change their addresses, they will kindly notify the new address to the Secretary. The omission to do this is likely to cause the loss of the JOURNALS and other communications.

Telegraphic Address.

The address of the Society has been registered at the Telegraph Office. Calcutta. Telegrams should be addressed " Astronomy," Calcutta.

The Library.

A subscription list exists and several members in Calcutta have subscribed and enabled the Council to make a beginning with the Library. Other members outside Calcutta, however, have not, except in one or two cases, yet come forward, and as the Library will be one of the most important adjuncts of the Society, and will be available to members both in and out of Calcutta, those who have not yet done so are invited to help the Society in making progress with this important branch of the work. Suggestions as to useful books for the Library will also be welcomed by the Librarian.

A number of books have already been received and can be borrowed by members in accordance with the Bye-Laws.

The books available can be ascertained from the Assistant Librarian. The reading-room of the Society in the Imperial Secretariat is now opened for the use of members daily from 5 to 7 P.M. except on Wednesdays and holidays, and from 3 to 5 P.M. on Saturdays, unless that day is a holiday.

The Journal.

This is the last number of the Journal for the Session 1911-12. The next Session will commence on the 1st October 1912 and the next Journal will issue in November 1912.

The following charges have been fixed for back numbers of the JOURNAL :—

For members.—Per copy 12 annas ; per volume Rs. 5.

The Star Chart.—As. 12 a copy.

For non-members.—Rs. 1-8 per copy

The Star Chart.—Rs. 2 a copy.

Subscriptions.

Subscriptions for the current Session fell due on 1st October 1911. Those who have not paid in their subscriptions are requested to remit them to the Treasurer without delay.

Papers for Meetings.

It is requested that drawings which accompany papers for reproduction in the JOURNAL may be made with Indian ink on white paper. This will insure a clear reproduction.

List of Instruments.

With a view to enable the Council to obtain a knowledge of the instrumental equipment of the members, it is requested that those members who possess any instrument suitable for astronomical work will kindly send details to Director of Instruments of its kind, size and power.

Alteration of Bye-Law 27.

The following Bye-Law has been proposed by Mr. Lee and passed by the Council for adoption at the next General Meeting of the Society:—

"*Revised Bye-Law No. 27.*—If a subscription be not paid within one month of the due date, a notice shall be given to the member that he is in arrear. If the subscription be not paid within five months of the due date the member shall be informed by a notice that if the subscription be not paid within six months of the due date the Journals and other Publications of the Society shall not be sent to the member until payment of the overdue subscription. If the subscription be not paid within twelve months of the due date, the defaulter shall cease to be a member of the Society, unless otherwise ordered by the Council. The Council may, at any time, reinstate such member upon payment of all arrears."

General Meeting.

The Annual General Meeting of the Society will be held on Tuesday, the 29th of October 1912, in the Imperial Secretariat (Treasury) Buildings, at 5 P.M.

The following business will be transacted:—

1. Minutes of the previous meeting.
2. Admission of members.

3. The alteration of Bye-Law 27.
4. The Report of the Society for the Session 1911-12.
5. The President's Address.
6. The announcement of the results of the election of the Council for 1912-13.

Addresses of Officers.

Owing to inconvenience which has arisen from addressing the Officers of the Society at their private address, it has been decided to receive communications on the business of the Society in future as follows :—

	To
Money orders or letters containing money or cheques.	U. L. BANERJEE, ESQ., Office of the Accountant-General, Bengal, 3, Koila Ghat Street, CALCUTTA.
All other communications	*(Name)* ....Esq. *(Designation)* ....of the Astronomical Society of India, Imperial Secretariat (Treasury) Buildings, Calcutta.

It is requested that the communications may be addressed accordingly.

Officers and Council.

FOR THE SESSION 1911-12.

(1) *President* . . . H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.

(2) *Vice-Presidents* . . (1) COL. S. G. BURRARD, R.E., C.S.I., F.R.S.
(2) J. EVERSHED, ESQ., F.R.A.S.
(3) SREE RAJA A. V. JUGGA RAO BAHADUR GARU, F.R.A.S., F.A.I., F.R.M.S., F.A.S. & C.
(4) H. H. THE MAHARAJA RANA BAHADUR SIR BHAWANI SINGH, K.C.S.I., F.R.A.S.

(3) *Secretary (Scientific)* . DR. E. P. HARRISON, PH.D.
Do. (Business) . P. N. MUKHERJI, ESQ., M.A., F.R.A.S., F.S.S.

(4) *Treasurer* . . . U. L. BANERJEE, ESQ., M.A.

Directors of Sections—
Lunar Section . . H. G. TOMKINS, ESQ., C.I.E., F.R.A.S.
Meteor Section . . P. C. BOSE, ESQ.
Variable Star Section . LIEUT.-COL. LENOX-CONYNGHAM, R.E., F.R.A.S.

Instrumental Director . S. WOODHOUSE, ESQ.
Director of Classes . . B. M. RAKSHIT, ESQ.
Librarian . . . C. T. LETTON, ESQ.
Editor . . . . J. J. MEIKLE, ESQ.

Other Members of the Council.

J. C. DUTT, ESQ., M.A., B.L.
F. W. HOWSE, ESQ.
A. T. MITRA, ESQ., M.A.
J. C. MITRA, ESQ., M.A., B.L.
C. W. PEAKE, ESQ., M.A.
SARODA CHARAN MITTER, ESQ., M.A., B.L.
W. J. SIMMONS, ESQ.
C. K. SIRCAR, ESQ., C.E., M.S.A., M.S.E.
W. A. LEE, ESQ., F.R.MET.S.
MISS ALICE MCLEOD